Khronos Fast Forward

Tomasz Bednarz, Director of Strategic Researcher Engagement, NVIDIA
Khronos Connects Software to Silicon

Open, royalty-free interoperability standards to harness the power of GPU, XR and multiprocessor hardware

3D graphics, augmented and virtual reality, parallel programming, inferencing and vision acceleration

Non-profit, member-driven standards organization, open to any company

Proven multi-company governance and Intellectual Property Framework

Founded in 2000
~ 200 Members | ~ 40% US, 30% Europe, 30% Asia
Khronos Active Standards

- **3D Graphics**
  - Desktop, Mobile and Web

- **3D Assets**
  - Authoring and Delivery

- **Portable XR**
  - Augmented and Virtual Reality

- **Parallel Computation**
  - Vision, Camera, Inferencing, Machine Learning

- **Safety Critical APIs**

Logos of various Khronos Group standards and projects are shown, including Vulkan, ANARI, glTF, COLLADA, OpenXRF, OpenCL, OpenVX, NNEF, SYCL, SPIR, WebGL, OpenGL, OpenGL ES, 3DCommerce, OpenGL sc, Vulkan sc, and SYCL sc.
Khronos Standards for Spatial Computing

- **OpenVX**: Vision and inferencing acceleration
- **OpenCL**: Runtime Control
- **OpenXR**: XR displays and devices
- **Vulkan**: Runtime Control
- **ANARI**: Pixels
- **WebGL**: 3D rendering acceleration

**Embedded camera, sensor and ISP**

**Runtime Control**

**Sensor Stream**

**Pose and scene data**

**Augmentation 3D Assets**

**3D Assets**
ANARI is an open cross-platform 3D rendering engine API that simplifies the development of portable 3D visualization applications using state-of-the-art rendering
Cross-Platform 3D Rendering Engine API

**Simplified Application Development**
High-level API to describe WHAT is to be rendered not HOW

**Application Portability**
Common API for ANY rendering-engine independent of vendor / platform

**ANARI 1.0 Specification Published**
Multiple implementations shipping and open-source SDK available
Rigorous API specification with Conformance Tests

**Scientific Visualization Beachhead**
Many types of application will benefit from using ANARI
Visualization Application Portability

**Before ANARI**

- VTK
- ParaView
- VMD
- VisIt
- Intel OSPRay
- AMD Radeon ProRender
- NVIDIA VisRTX
- Others...

**After ANARI**

- VTK
- ParaView
- VMD
- VisIt
- Intel OSPRay
- AMD Radeon ProRender
- NVIDIA VisRTX
- Others...

ANARI applications are portable to any engine supporting the ANARI API
Independently of vendor, platform or ecosystem
ANARI Development Stack

Processing to construct a scene description with application-specific structures, traversals, and metadata

ANARI API used to build in-memory scene representation
NO rendering details prescribed
C99 frontend API dispatch library with C++ type-safe wrappers
Extensible API design with installable development layers

Engines use in-memory scene representation to drive rendering operations

Explicit control over hardware resources and operations

Scene Graphs

Apps
and Engines

Rendering Engines
Intel OSPRay, Radeon ProRender, NVIDIA VisRTX etc.

Acceleration APIs
Vulkan, OpenGL, DX12, Metal
Embree, OptiX, Radeon Rays, CUDA, OpenCL, etc.

Hardware
CPUs, GPUs etc.

VMD Rendering using ANARI
Minimal Cell, 87M Beads
Martini v3 force field, U. Illinois
Kitware Adds ANARI Support to VTK

Simplify Access to Accelerated 3D Rendering Engines

• At Siggraph 2023 NIST demonstrated multiple ANARI-enabled visualization tools including VMD, VTK, & VTK-m

“We are very excited about the release of ANARI 1.0 and its integration with VTK. ANARI will help us provide our users with natively accelerated high-end rendering capabilities on multiple platforms. This capability is essential for the scientific discovery process.”

Berk Geveci, senior director of Scientific Computing, Kitware.
ANARI - Try It Today!

• Open-source ANARI SDK
  - Loadable debug and trace layers
  - Example applications demonstrating ANARI concepts

• Implementations shipping now on rendering engines from AMD, Intel and NVIDIA
  - AMD Radeon ProRender
  - Intel OSPRay
  - NVIDIA VisRTX + VisGL

• ANARI beyond Scientific Visualization
  - Blender and Omniverse

Proof-of-concept Blender Add-On
Amazon Lumberyard Bistro
NVIDIA Open Research Content Archive (ORCA) 2017

ANARI-USD Brings ANARI applications to USD/Omniverse
NVIDIA OmniGraph geometry processing

Give us your feedback and requirements on ANARI GitHub
What rendering features important to your application domain?
For what new application domains and use cases would you use ANARI?
https://www.khronos.org/anari
https://github.com/KhronosGroup/ANARI-Docs
https://github.com/KhronosGroup/ANARI-SDK
Vulkan is an open, cross-platform low-level and explicit API for achieving high-performance graphics and compute on GPUs
Vulkan Design and Evolution

A modern API for graphics and compute on GPUs
  • Descended from OpenGL / OpenGL ES
  • Radically cross-platform
  • One API across desktop and mobile

No-compromise focus on performance
  • Driving use case is AAA games

Developer has control / responsibility for
  • Memory and object management | Scheduling and synchronization | Multithreading | Error checking

1.0 / 2016
1.1 / 2018
1.2 / 2020
1.3 / 2022
Vulkan Adoption

<table>
<thead>
<tr>
<th>Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>CINDER</td>
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<table>
<thead>
<tr>
<th>Platforms</th>
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<tbody>
<tr>
<td>Windows 10</td>
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<tr>
<td>Windows 11</td>
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<table>
<thead>
<tr>
<th>Desktop and Mobile GPUs and SOCs</th>
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<tbody>
<tr>
<td>AMD</td>
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</tbody>
</table>

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

http://vulkan.gpuinfo.org/
Vulkan Applications

Desktop Games

Not Games at All

Mobile Games
Vulkan SDK Downloads

Windows SDK

~35K/week
Vulkan Video

- Video stream processing integrated into Vulkan’s explicit API framework
  - Explicit, fine-grained application control over resource management & synchronization
  - Video encode/decode, GPU compute, composition, and rendering seamlessly integrated in one runtime
  - More details at Vulkan Video Deep Dive Presentation

- First cross-platform, cross-vendor accelerated video encode/decode API
  - Scaling from embedded to PC to data center

- FFmpeg 6.1 Released With Vulkan Video Decoding
  - In November 2023

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**Decode** | **Encode**
---|---
H.264 | Final
H.265 | Final
AV1 | 1Q24
H.264 | 4Q23
H.265 | 4Q23
AV1 | 2024

**Specs**
- FFmpeg 6.1 Released With Vulkan Video Decoding
- In November 2023

**Drivers**
- Managed by App/SDK
- Managed by App/SDK
- Managed by App/SDK
- Managed by App/SDK

Vulkan Video Decoding
- VkBuffers for input bitstream
- VkImage* for VkImage(s) with Output Images
- Use of standard Vulkan command queues and synchronization

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Vulkan Development on Apple

Vulkan SDK, Layers and Tools on Mac
Streamlines application development for Apple devices

Vulkan SDK Running on macOS

SPIRV-Cross
Open-source disassembler
Converts SPIR-V shaders to Metal Shading Language

macOS / iOS / tvOS
Vulkan to Metal API Mapping Layer

gpuinfo.org
Public Database

Profile JSON
Config Files

Database Export

Database Upload

Hardware Capability Viewer
for macOS and iOS on app store

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OpenXR provides cross-platform, high-performance access directly into diverse XR device runtimes across multiple platforms.
OpenXR Cross-Platform Portability

Applications and engines can portably access any OpenXR-conformant hardware

Before OpenXR: Applications and engines needed separate proprietary code for each device on the market.

OpenXR provides a single cross-platform, high-performance API between applications and all conformant devices.
## OpenXR Adopters

<table>
<thead>
<tr>
<th>HoloLens and Mixed Reality Headsets. Hand and eye tracking extensions</th>
<th>Rift S, Quest, Quest 2 and Quest Pro. Meta Deprecated own API for OpenXR</th>
<th>Vive Focus 3, Vive Cosmos, Vive XR Elite, Vive Wave Runtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEAMVR®</td>
<td>VALVE</td>
<td>MONADO</td>
</tr>
<tr>
<td>Valve Deprecated OpenVR APIs in favor of OpenXR</td>
<td>All Varjo Headsets are fully compliant (VR-1, XR-1, XR-3, VR-3)</td>
<td>Collabora’s Monado open-source OpenXR Implementation</td>
</tr>
<tr>
<td>Magic Leap 2</td>
<td>XREAL Light and XREAL X</td>
<td>Qualcomm Snapdragon Spaces XR Development Platform</td>
</tr>
<tr>
<td>Spatial Labs Display Series</td>
<td>Neo 3 and Pico 4</td>
<td>Spatial Reality Display</td>
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Engines, Browsers, and Libraries with OpenXR

<table>
<thead>
<tr>
<th>Engine/Browser/Library</th>
<th>Support Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unreal Engine</td>
<td>Unreal has been providing support since 4.24. UE 5.0 support OpenXR</td>
</tr>
<tr>
<td>Unity</td>
<td>Unity’s OpenXR plugin available since 2020 LTS</td>
</tr>
<tr>
<td>Godot</td>
<td>Godot provides OpenXR support since March 20233 (Core 4.0 Alpha 4)</td>
</tr>
<tr>
<td>stereokit</td>
<td>Open source mixed reality library for building HoloLens and VR applications</td>
</tr>
<tr>
<td>NVIDIA Omniverse</td>
<td>NVIDIA Omniverse and CloudXR Platforms</td>
</tr>
<tr>
<td>WebXR in Chrome, Edge,</td>
<td>WebXR in Chrome, Edge, and Firefox uses OpenXR as the default backend</td>
</tr>
</tbody>
</table>
# OpenXR Games and Applications

<table>
<thead>
<tr>
<th>Blender</th>
<th>Adobe Substance 3D Modeller</th>
<th>Kitware’s Paraview</th>
<th>Meta Horizon Workrooms</th>
<th>OpenBrush</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses OpenXR for native scene inspection in VR</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for Desktop and Quest support</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>War Thunder</th>
<th>Cubism</th>
<th>Vermillion</th>
<th>The Light Brigade</th>
<th>XPlane12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now uses OpenXR</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for VR support</td>
</tr>
</tbody>
</table>

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<tr>
<th>Minecraft</th>
<th>Microsoft Flight Simulator</th>
<th>Zombieland: Headshot Fever</th>
<th>Phasmophobia</th>
<th>Beat Saber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses OpenXR for desktop VR support</td>
<td>Uses OpenXR for VR support</td>
<td>Uses OpenXR for VR support</td>
<td>Switched from OpenVR to OpenXR</td>
<td>Uses OpenXR on PC</td>
</tr>
</tbody>
</table>

Supports over 27 devices thanks to OpenXR
OpenXR SDK 1.0.32 - November 2023

- Hand tracking and interaction improvements
- Improved support for Android-based devices
- OpenXR Metal (Mac OS) support in the works
- Improved compatibility with API Layers
- Vendors preparing to align on scene understanding API
OpenXR CTS 1.0.30 - October 2023

- More hand tracking tests to standardize across platforms
- Tests for all supported rendering formats (Vulkan, D3D12, etc)
- Added Console Only Testing (skip interactive testing)
- Added tests to enforce specification timing/order of events
Monado from Collabora

- Open source OpenXR Runtime and Framework
- Framework provides building blocks to simplify XR development

Monado OpenXR framework for creating OpenXR runtimes

- Spatial Vision Engine
- OpenXR state trackers
- Compositor
- Interaction Engine
- Tools

Monada OpenXR Runtime

- hmd drivers
- hmd display
- controller
- camera / depth sensor
- slam tracker
- camera & IMU
Coming soon...

- **Meta XR Simulator** (out now!)
- Increased Accessibility
- Expanded haptics support
- Controller render models (glTF)
- Metal (Mac OS) Support
- New extensions
- Tutorials (January 2024)
Khronos and W3C: Bringing XR to the Web

XR Applications and Engines use an API from both the 3D and XR Stacks

3D Stack
Driving GPUs to render scenes and augmentations

XR Stack
Handling XR Devices for creating UI

Engines
three.js, babylon.js, unity, Unreal Engine, GODOT

WebGL, WebXR, WebGPU, OpenGL ES, Vulkan, OpenXR

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WebGL is a cross-platform, royalty-free open web standard for 3D graphics based on OpenGL ES and exposed as an HTML5 Canvas
WebGL Update

- Khronos is fully supporting development of WebGPU at W3C
  - Working for a smooth transition for developers between WebGL and WebGPU
  - WebGPU brings GPU Compute to the Web using Vulkan/DX12/Metal backends
- WebGL is pervasive and will be used by many applications for many years
  - Khronos will evolve the WebGL specification and support multiple implementations
    - ANGLE's Metal backend supports WebGL 2.0 in Safari on macOS/iOS
    - Coming soon to Chromium on macOS
    - display-p3 support is in progress in Firefox

WebGL 2.0 is available on 95% of browsers
New WebGL Extensions

- **Pixel Local Storage** Extension
  - Developed by Chris Dalton from Rive
  - Programmable blending and other use cases
  - In Draft in Chrome Canary
    - Enable WebGL draft extensions in about:flags
  - [Live demo](#) implements blend_equation_advanced
    - (source code)

- Multiple useful **extensions** are being ported from OpenGL ES
  - EXT_blend_func_extended
  - EXT_clip_control
  - EXT_conservative_depth
  - EXT_depth_clamp
  - EXT_polygon_offset_clamp
  - EXT_render_snorm
  - EXT_texture_mirror_clamp_to_edge
  - NV_shader_noperspective_interpolation
  - OES_sample_variables
  - OES_shader_multisample_interpolation
  - WEBGL_clip_cull_distance
  - WEBGL_polygon_mode
  - WEBGL_render_shared_exponent
  - WEBGL_stencil_texturing
The royalty-free specification for the efficient transmission and loading of 3D scenes and models by engines and applications.
glTF Pervasive Adoption
glTF Design Principles

- Innovate on pervasive deployment of proven technology
- Precise specification and open-source tooling for multi-vendor consistency
- Enable cloud, desktop and mobile (native and web)
- Pure file format - no mandated run-time behavior
- Optimize for run-time use cases
- Be a cooperative distillation target for authoring formats
glTF 2.0 Released as an ISO/IEC Standard

- Solidifies glTF’s global recognition and adoption as a 3D asset format
- ISO/IEC 12331:2002 captures identical functionality to glTF 2.0
- Khronos will continue to evolve glTF at its own pace
- Will regularly update ISO/IEC 12113
The Evolution of PBR in glTF

Metal / Rough
Clearcoat
Transmission
Sheen
IoR
Specular
Iridescence
Volume
Anisotropy
Emissive

Released in 2022/23

KHR_materials_emissive_strength
KHR_materials_anisotropy
KHR_materials_iridescence
glTF Interactivity

- Portable description of how content should respond to user actions or events
  - Interactivity defined by a Node-based graph
- Distillation of engine accepted practice
  - Unity (Visual Scripting), Unreal (Blueprints), Nvidia Omniverse (Action Graph)
  - Similar design process to PBR extensions
- Enables simple interactive applications
  - Games, Education, Design Review, e-commerce
Let’s Get Moving with Physics

- Express the physics properties of assets
  - Distillation of widely adopted physics engines practices
  - Provides procedural animation and makes scenes more dynamic
- Rigid Bodies: Collision Geometry, Motions, Materials, Joints, Filters ...
- Draft extension: khr.io/120

gltf Physics Webinar
Webinar Oct 31, 2023
khr.io/121
**glTFX : glTF eXternal References**

- Meet user requirement to reference multiple glTF assets
  - Complex scenes, Level-of-Detail, streaming, smart loading, scene change...
- Adds a new glTF file type (glTFX)
  - Contains eXternal reference to glTF files as
  - New file does not specify any meshes, animations, materials, etc. directly
- Draft spec: [khr.io/127](khr.io/127)

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**Scene**

- Node Bike 1
- Node Bike 2
- Node Shop
- .glTF Frame 1
- .glTF Frame 2
- .glTF Tire
- .glTF Rack

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**Webinar**
Watch the Recording
[khr.io/122](khr.io/122)
glTF-Blender-IO

• New features / enhancements
  - In 4.0 (beta)
    - Better PBR Material export (thanks to new Principled BSDF)
    - Better Rigging roundtrip for glTF editing
    - Sparse Accessors (Better file size)
    - GPU Instancing (EXT_mesh_gpu_instancing)
    - WebP textures (EXT_texture_webp)
    - Better skin influence bone number option (Godot Engine)
glTF Viewer for iOS

- Khronos Releases Open-Source iOS App for Viewing glTF Files
  - Available on the Apple App Store and supports AR mode
  - Source code available on GitHub under the Apache 2.0 license
glTF and USD are Complementary

Khronos and AOUSD have entered into a liaison agreement

Designed for compact, fast run-time delivery

Designed for powerful authoring collaboration

Aligning the glTF and USD ecosystems can be of significant benefit to the industry

glTF aims to be a seamless distillation target for USD for widespread distribution with lossless roundtripping
KTX 2.0 Supports Basis Universal Compression

Open-source Basis Universal encoder with supercompression produces compact textures for transmission.

Open-source tools pack supercompressed textures into KTX 2.0 container and then pack KTX textures into glTF assets.

Open-source C++ and WebAssembly transcoding to GPU compressed formats.

Use GPU compressed textures native to platform
- Desktop: BC*
- Mobile: ETC1/2, PVRTC1, ASTC

Universal GPU-Compressed Textures

Compact, visually rich, assets that can be efficiently rendered on diverse platforms.

Texture Assets .png or .jpg
Encode and Supercompress
Basis Universal supercompressed textures in KTX 2.0 container
Transcode ON THE FLY to GPU formats
GPU Compressed Texture
GPU Compressed Texture
GPU Compressed Texture

Open-source Basis Universal encoder with supercompression produces compact textures for transmission.
Helping deploy 3D in e-commerce at scale by extending the glTF 3D standard asset format and driving the 3D commerce eco-system
Power of 3D in e-commerce

3D in e-commerce can:

- Lower costs
- Increase sales
- Reduce returns
- Increase customer satisfaction and loyalty!

BUT to achieve deployment at industrial scale, we need:

Industry cooperation to streamline the design, distribution & deployment of millions of realistic and reliable 3D assets onto multiple consumer platforms.
Importance of Standardisation

- **Visual Consistency**
  - Getting as close to the real thing as possible increases e-commerce conversion, online duration for consumers & reduces returns of physical products, increasing brand trust.

- **Load time**
  - Processing & bandwidth can be varied therefore the lower the loading time the better. glTF stores 3D model information in JSON format. The use of JSON minimizes both the size of 3D assets and the runtime processing needed to unpack and use those assets.

- **Experience**
  - The use of standardised file formats provides a consistent experiences across a variety of devices and platforms. What is viewed on the web should be the same on another device whether that browsing, AR, VR or MR.

- **Open Metaverse & Wearable AR (New Customers)**
  - As new devices become more readily available and more affordable, so does the need to bring a consistent experience in other types of space and device. The demographic changes as does the requirement.
Under Exploration & Development

- **Skeletal & Facial Anchoring**
  - Exploring standards for facial anchoring, wrist anchoring & virtual try.

- **Scene Composition**
  - Needs and use cases for multi-sku, interactive and physics based experiences for use in e-commerce.

- **Visual Consistency, Tone Mapping & Colour**
  - Tone mapping, consistency and colour range on a range of engines, platforms and browsers.

- **Interoperable tools & standards**
  - Tools and standards that operate in conjunction with one another.

- **Tutorials, guides & videos**
  - Tutorials, guides and videos on RoI, e-commerce experts 1 to 1 interviews.

- **Asset Creation Guidelines and open source Asset Validator**
  - New and updated set of guidelines for building standardised 3D content and a tool to actively guide the creation, and assess the reliability of assets

- **NeRF (Neural Radiance Fields), Gaussian Splatting, Machine Learning & AI in 3D scanning & representation.**
  - Using generative AI in 3D Asset & scene creation.
Wider Industry Impact

glTF Extensions for 3D Commerce Use Cases

- Expanding power and flexibility of asset format standards for increasingly realistic models and enterprise process integration
- Build Once, Use Everywhere
- Inspiring tools and techniques to effectively create 3D assets that can be reliably used everywhere
- Visual Consistency
- Ensuring that 3D objects and scenes are being accurately displayed by diverse apps and engines
Get Involved!

Join Khronos and the 3D Commerce Working Group

We welcome both commerce and technology companies.  
Influence and gain early access to extensions, tools & programs.  
Define industry leading standards with industry experts.

Or join the 3D Commerce Advisory Forum

Provide insights, requirements and feedback to the working group.  
Contribute to the conversation.  
Free of charge to any interested company.

https://www.khronos.org/3dcommerce/  
3dcommerce-feedback@khronos.org
Thank You! Have a Great Show!

More Information

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memberservices@khronosgroup.org