



OPEN STANDARDS IN THE CLIENT-TO-CLOUD REVOLUTION

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THE INTERNATIONAL
FUTURE COMPUTING
SUMMIT



Khronos is an **open, non-profit**, 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** such as **inferencing** and **vision processing**



>150 Members ~ 40% US, 30% Europe, 30% Asia

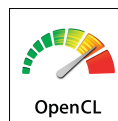
Some Khronos Standards Relevant to the Client-to-Cloud Revolution



Vision and Inferencing
Acceleration



3D on
the Web



Heterogeneous
Parallel Compute



Portable
AR and VR



C++ Parallel
Compute

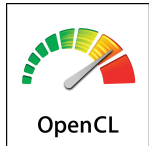
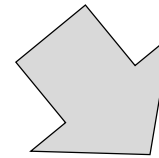
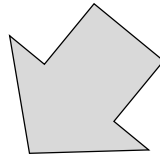


GPU
Acceleration

Khronos Standards For Client-to-cloud



Enabling the Client-to-cloud Revolution through the future computing pillars of innovative content and applications via compute performance and platforms and immersive technology



**Heterogeneous Parallel Compute
Vision and Inferencing Acceleration**



**High-performance 3D and HMD control
for Immersive AR and VR Experiences**



The Need for Interoperability Standards

True OPEN Standards

Are precisely defined specifications with conformance tests to promote true cross-vendor interoperability

MAY (usually) use open source for tools and sample implementations

Are not controlled by a single company - but by the whole industry

Are freely available to implement and use by any company without royalty payments

Are created under a well-defined IP Framework to protect implementers

AND the standards creator's Intellectual Property

Interoperability Standards Enable Communication



Application
Programming
Interfaces

Hardware <-> Software

3D Asset Formats
Tools <-> Applications

Wireless Standards
Servers <-> Devices

And many more...

**E.g. XR will need a constellation
of 100s of industry standards from
many standards organizations**

Standards Grow Markets

By reducing consumer confusion and
increasing capabilities and usability

Standards Reduce Costs

By sharing development between
many companies and driving volume

Standards Accelerate Time to Market

With well-proven testing and interoperability

Standards Do Not Stifle Innovation

Companies can compete on implementation
quality, performance, power etc. etc.

Vulkan and New Generation GPU APIs

Modern architecture | Low overhead | Multi-thread friendly
EXPLICIT GPU access for EFFICIENT, LOW-LATENCY,
PREDICTABLE performance



Vulkan is a non-proprietary, royalty-free open standard
Portable across multiple platforms - desktop, mobile and embedded

Pervasive Vulkan



Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms



<http://vulkan.gpuinfo.org/>

Platforms



Desktop



Android
(Android 7.0+)
(Vulkan 1.1 required on Android Q)



Apple
(via porting
layers)



Media Players



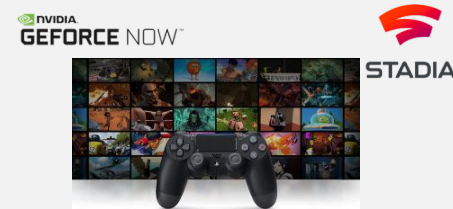
Consoles



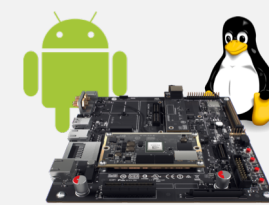
Virtual Reality



Cloud Services



Game Streaming



Embedded

Game Engines



$$\text{XR} = \text{AR} + \text{VR}$$

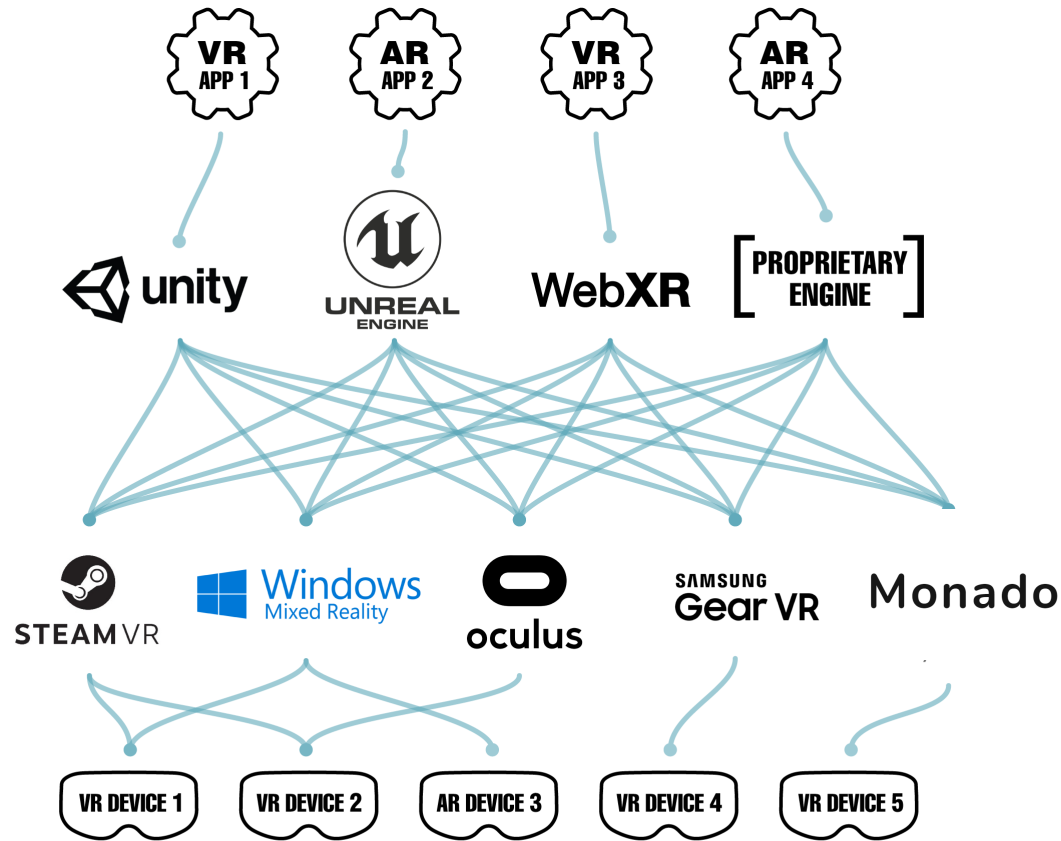
OpenXR provides cross-platform, high-performance access to AR and VR platforms and devices

Virtual Reality



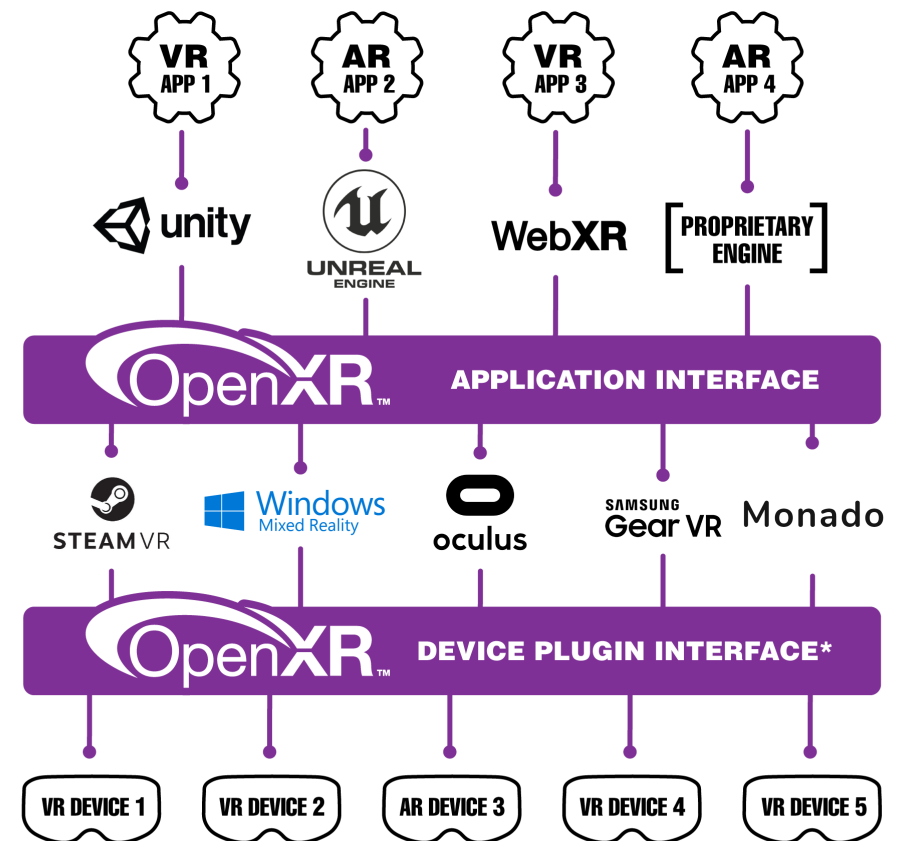
Augmented Reality

OpenXR - Solving XR Fragmentation



Before OpenXR

XR Market Fragmentation



After OpenXR

Wide interoperability of XR apps and devices

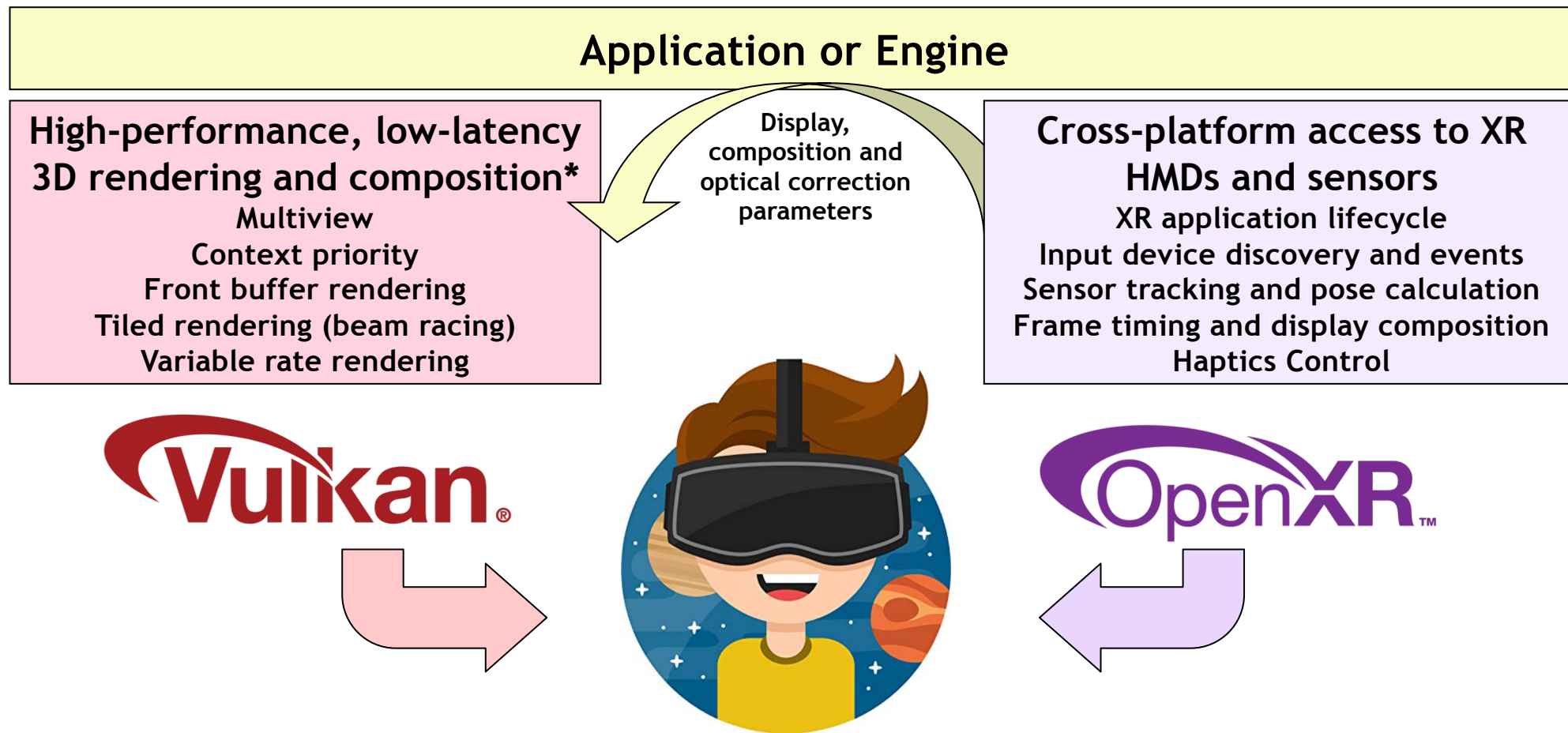
* OpenXR 1.0 is focused on enabling cross-platform applications. Optional device plugin interface will be supported post V1.0

** Check OpenXR Landing Page for exact availability of OpenXR in shipping run-times and devices www.khronos.org/openxr

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OpenXR is used with a 3D API



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

Companies Publicly Supporting OpenXR



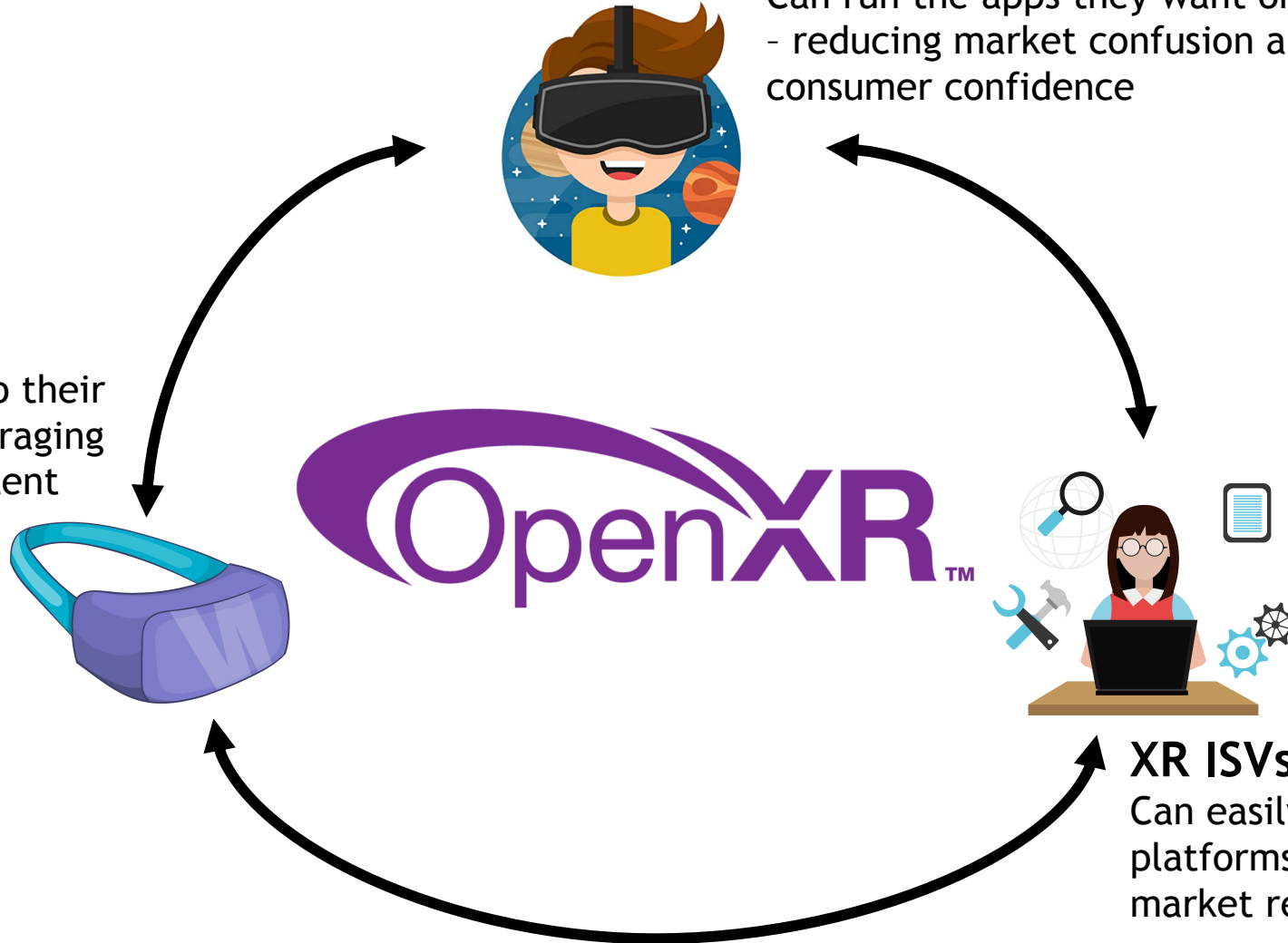
OpenXR is a collaborative design
Integrating many lessons from proprietary 'first-generation' XR API designs

OpenXR Win-Win-Win

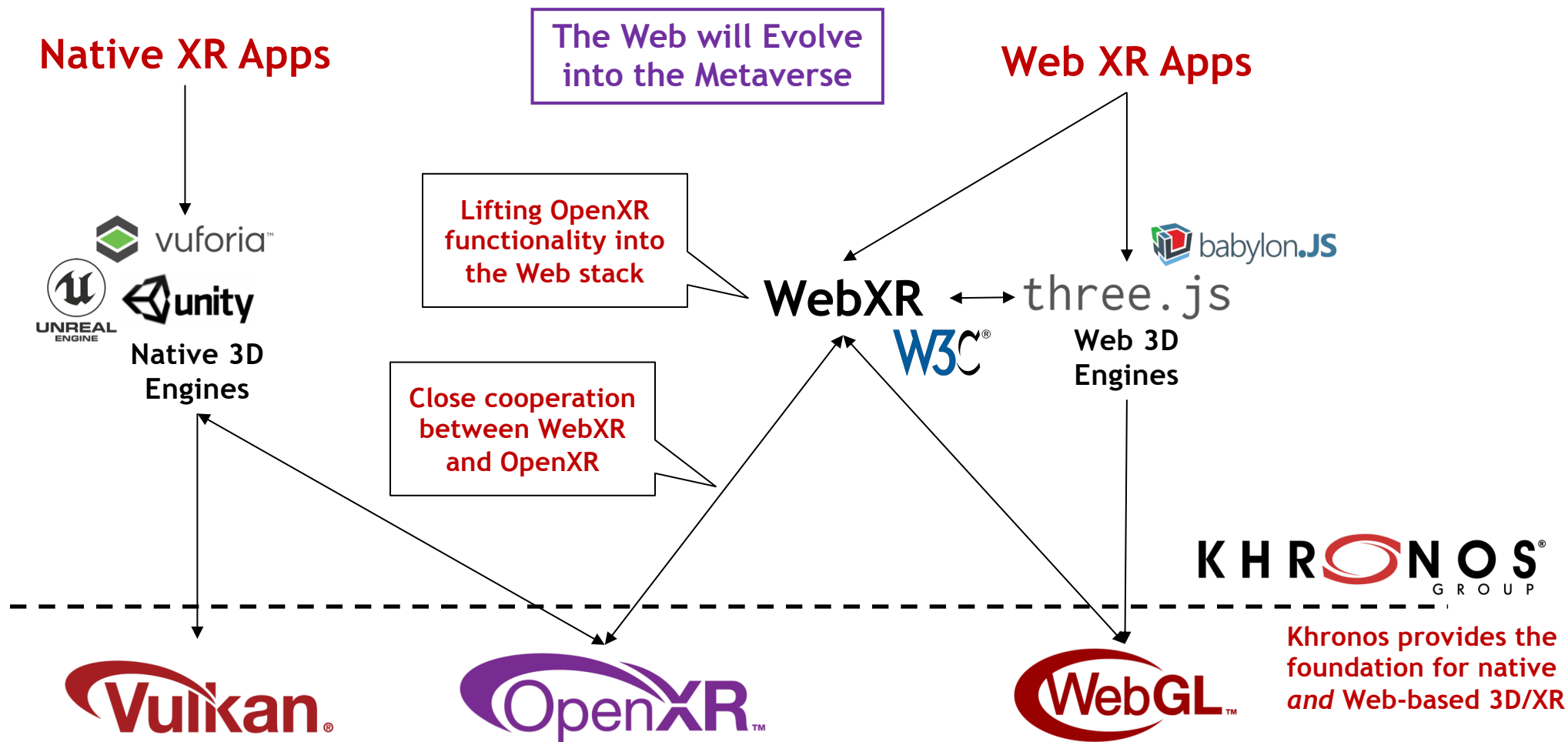
XR Vendors
Can bring more applications onto their platform by leveraging the OpenXR content ecosystem

XR End-Users
Can run the apps they want on their system
- reducing market confusion and increasing consumer confidence

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



Bringing XR to the Web

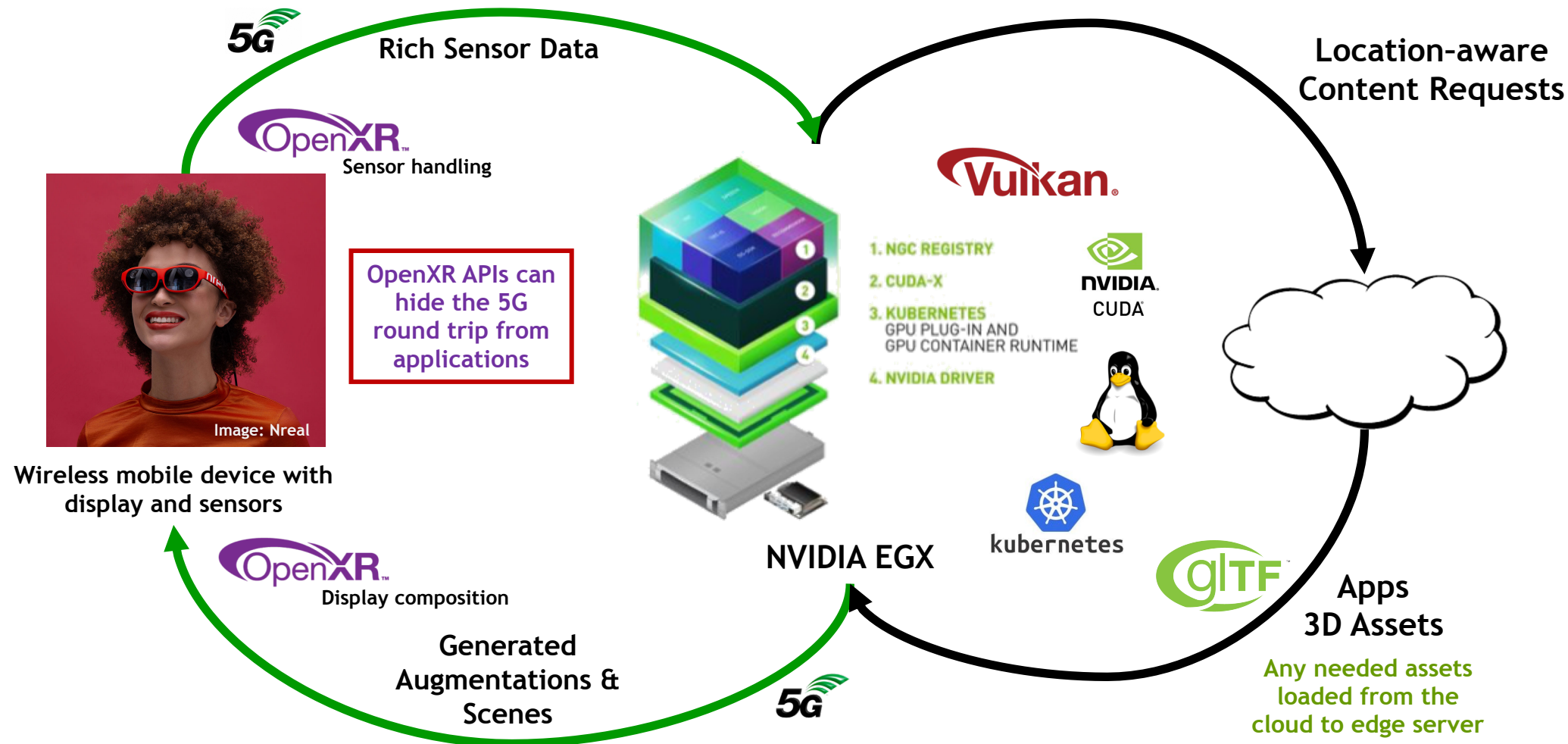


XR and 5G

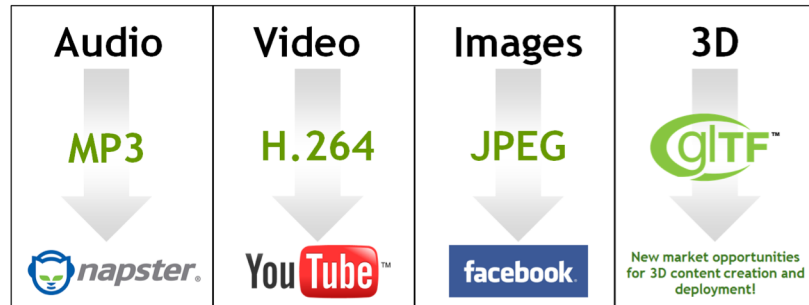
Leveraging High Bandwidth and Low Latency

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



glTF Real-time 3D Asset Transmission



glTF is an efficient, reliable run-time 3D transmission format with advanced photorealistic functionality



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



glTF 2.0 - June 2017
Physically Based Rendering

Functionality in Development

- Draco Mesh Compression
- Universal Compressed Textures
- Second generation PBR
(absorption/attenuation, clear coat,
subsurface scattering, anisotropy)
- Subdivision surfaces



Dedicated 3D Authoring Tools



Authoring Tools that Export 3D



VR / AR Authoring Tools



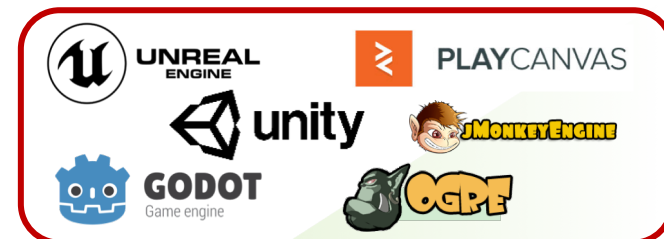
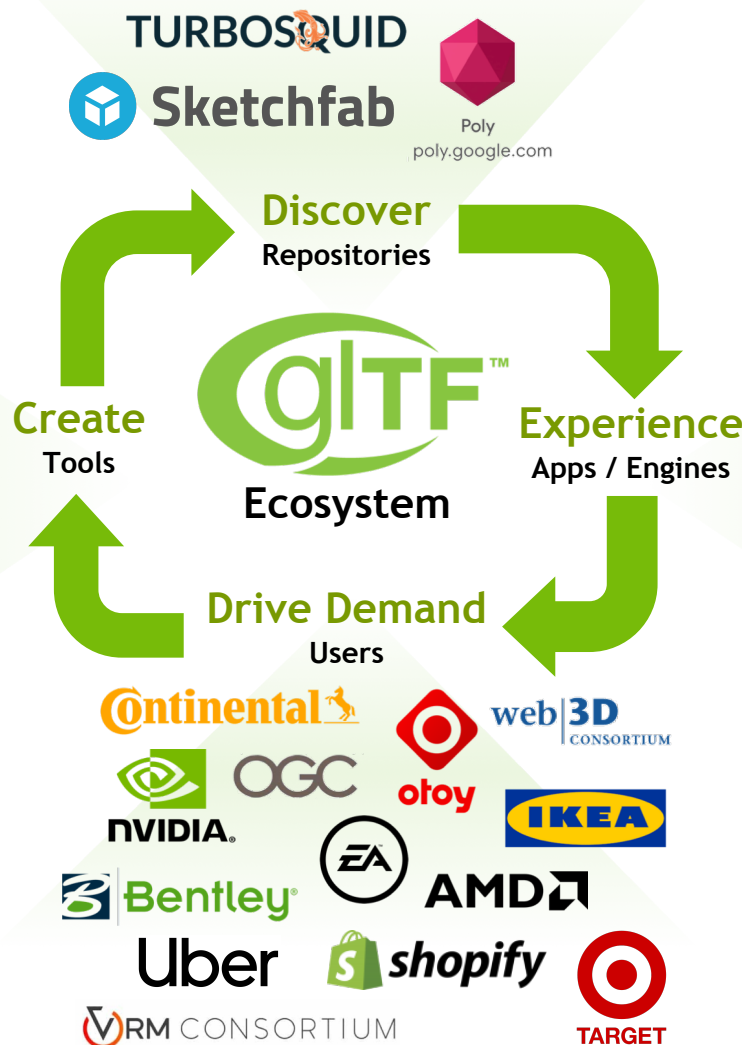
3D Scanning Tools



Convertors and Optimizers



Validation and Reference Tools



Game Engines



Web Engines



Apps and Engines

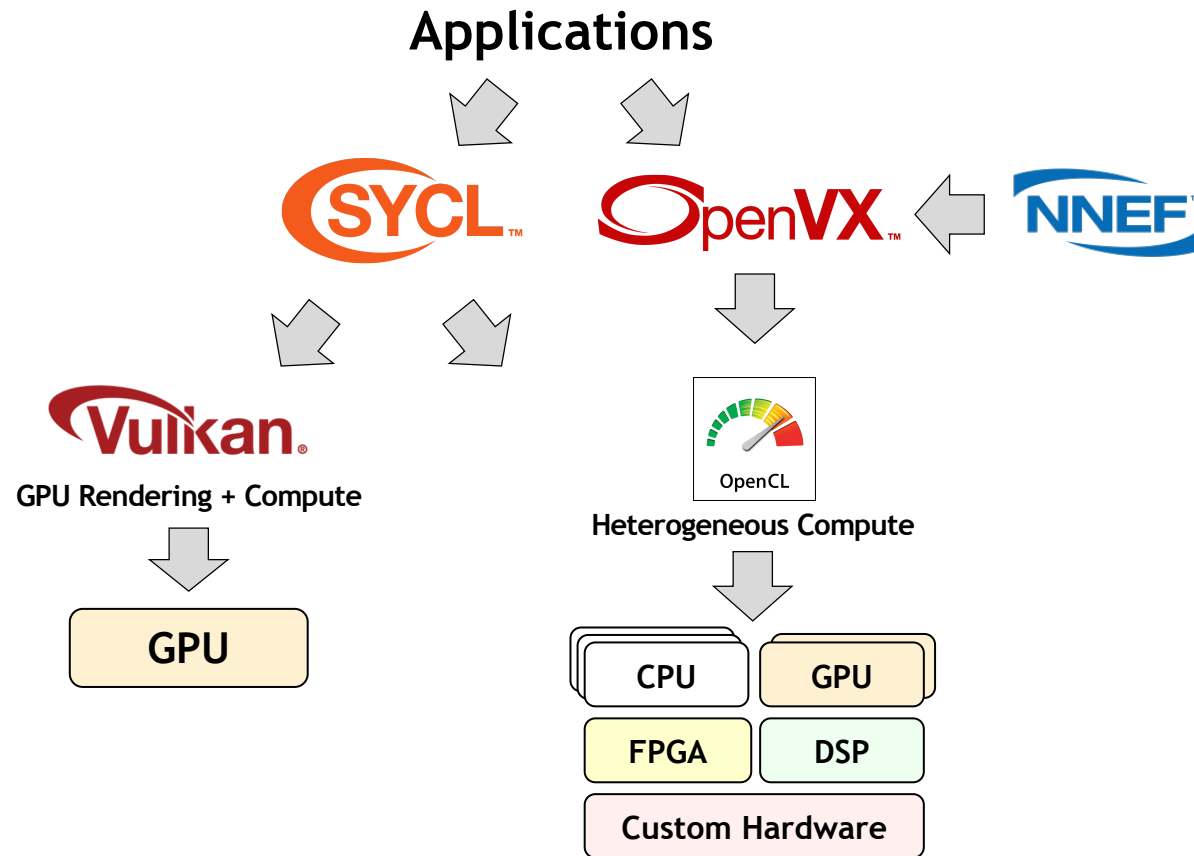


VR / AR Apps and Engines



Productivity and Social Apps

Khronos Open Standard Compute APIs



SYCL enables parallel applications using single source STANDARD C++
C++ templates, lambda functions separate host & device-accelerated code
Evolved from being a layer over OpenCL - now looking to layer over other APIs - including Vulkan



OpenVX provides high-level graph programming for portable, efficient vision and inferencing acceleration
Portable to any processor architecture
Optimized drivers and shipped with silicon



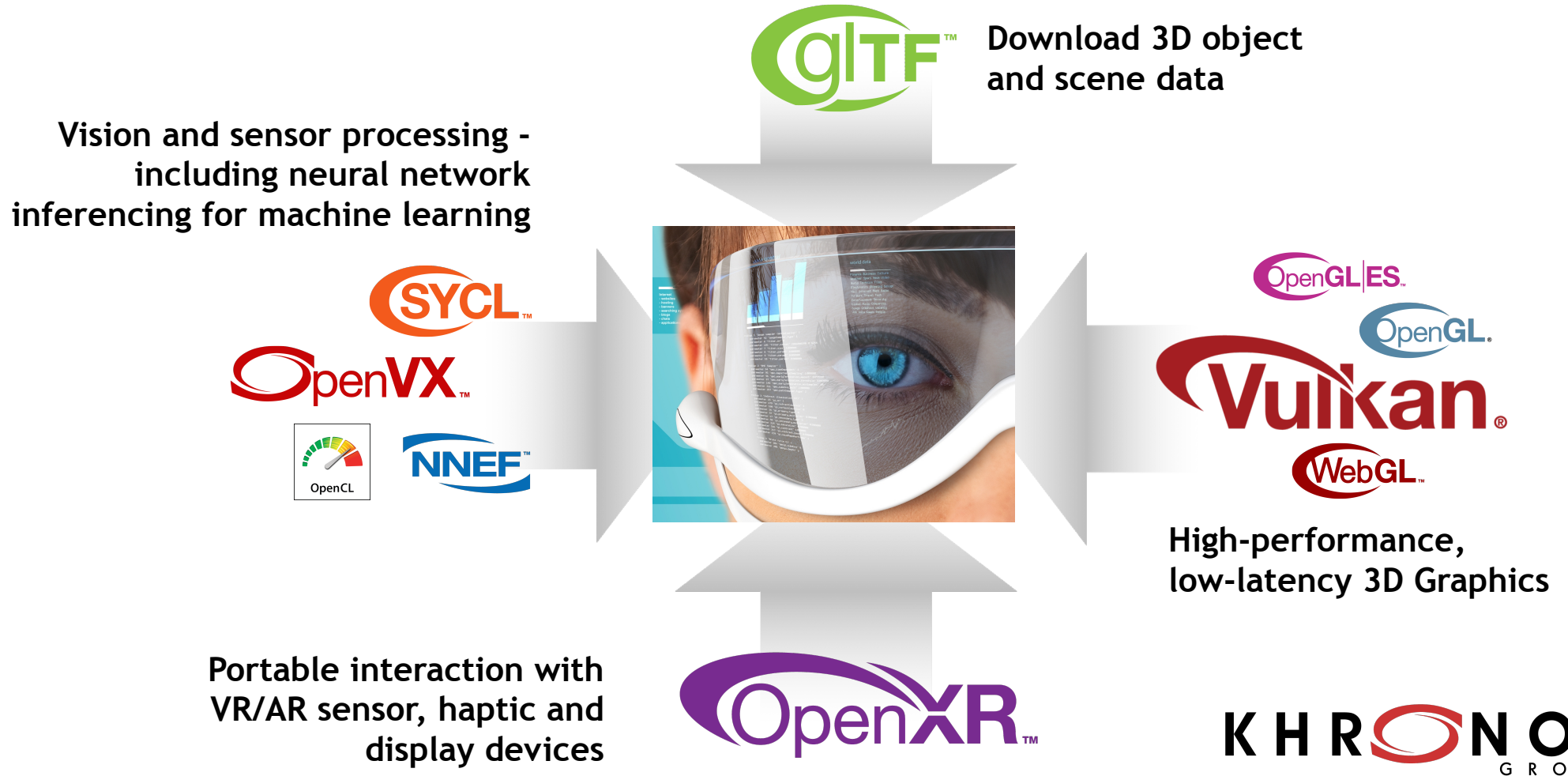
NNEF enables import of trained Neural Networks to inferencing engines
Evolved by and for the hardware processor vendor community



OpenCL provides a low-level programming and runtime framework
OpenCL C and C++ kernels compiled and loaded to any available device
Explicit control over memory allocation and parallel task execution
Simpler, relatively lightweight and more flexible than GPU APIs

Increasing interest in parallel heterogonous compute acceleration to combat the 'End of Moore's Law'

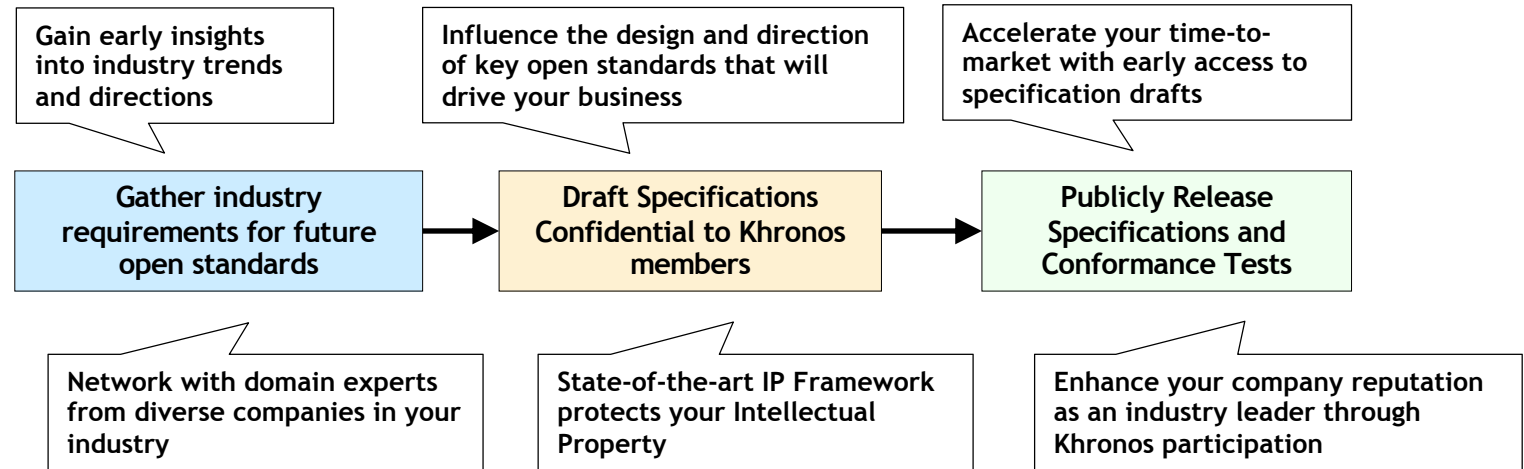
Khronos Standards Immersive Computing



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Thank You and Resources

- These slides and information on Khronos Standards
 - www.khronos.org
- Any company is welcome to join Khronos
 - <https://www.khronos.org/members/>
- Neil Trevett
 - ntrevett@nvidia.com | [@neilt3d](https://twitter.com/neilt3d)



Benefits of Khronos membership