



Fast Forward

August 2018

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www.khronos.org















GENERATIONS / VANCOUVER
12-16 AUGUST
SIGGRAPH2018

Khronos Mission



Khronos is an International Industry Consortium creating royalty-free, **open standards** to enable software to access hardware acceleration for **3D Graphics, Virtual and Augmented Reality, Parallel Computing, Neural Networks and Vision Processing**

Khronos *Fast Forward*

	Run-time APIs	File Formats
3D Graphics	   	
Heterogenous Compute (Parallel Processing)	  	
VR and AR Vision and Inferencing	 	

Vulkan and New Generation GPU APIs

Non-proprietary, royalty-free open standard 'By the industry for the industry'

Portable across multiple platforms - desktop and mobile

Modern architecture | Low overhead | Multi-thread friendly

EXPLICIT GPU access for EFFICIENT, LOW-LATENCY,
PREDICTABLE performance



Vulkan is available on Android 7.0+

Pervasive Vulkan



Major GPU Companies supporting Vulkan for Desktop and Mobile Platforms



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

Platforms



Desktop



Mobile
(Android 7.0+)



Media Players



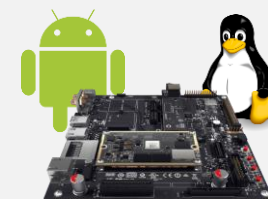
Consoles



Virtual Reality



Cloud Services



Embedded

Game Engines



Vulkan 1.1 Launch and Ongoing Momentum

Strengthening the Ecosystem

- Improved developer tools (SDK, validation/debug layers)
- More rigorous conformance testing
- Shader toolchain improvements (size, speed, robustness)
- Shading language flexibility - HLSL and OpenCL C support
- Vulkan Public Ecosystem Forum

Building Vulkan's Future

- Deliver complete ecosystem - not just specs
- Listen and prioritize developer needs
- Drive GPU technology

Released Vulkan 1.1 Extensions

- KHR_draw_indirect_count
Source draw count parameter from a buffer in GPU-writable memory for greater flexibility for GPU-generated work
- KHR_8bit_storage
8-bit types in uniform and storage buffers for improved compute support in apps such as inferencing and vision
- EXT_descriptor_indexing
Dynamically non-uniform (aka bindless) resource access
Required by some modern game engine architectures

Discussions in Flight

- Reduced precision arithmetic types in shaders
- Detailed driver property queries
- Variable-resolution rendering
- Cross-vendor performance counter queries
- Memory residency management
- Depth/stencil resolve
- Ray tracing
- Video
- New synchronization primitives

Widening Platform Support

- Pervasive GPU vendor native driver availability
- Open source drivers - ANV (Intel), AMDVLK/RADV (AMD)
- Port Vulkan apps to macOS/iOS and DX12

Vulkan 1.0 Extensions

Maintenance updates plus additional functionality

- Explicit Building Blocks for VR:
e.g. multiview

- Explicit Building Blocks for
Homogeneous Multi-GPU

- Enhanced Windows System Integration

- Increased Shader Flexibility:

- 16 bit storage, Variable Pointers

- Enhanced Cross-Process and
Cross-API Sharing



March 2018
Vulkan 1.1

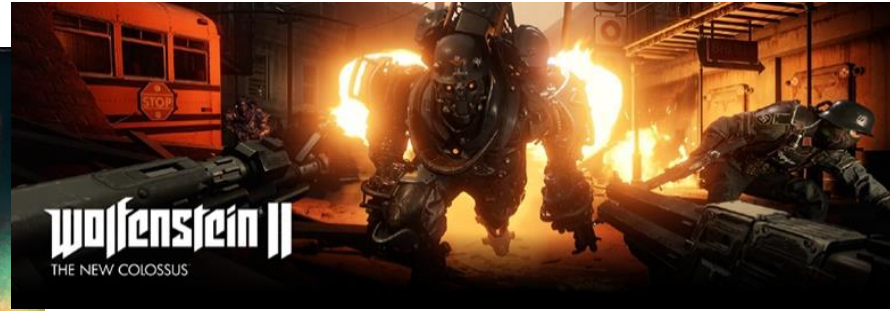
Integration of 1.0 Extensions.
New Technology into Core e.g.
Subgroup Operations



February 2016
Vulkan 1.0

Explicit Access to
GPU Acceleration

Content is shipping on desktop...



Vulkan-only AAA
Titles on PC

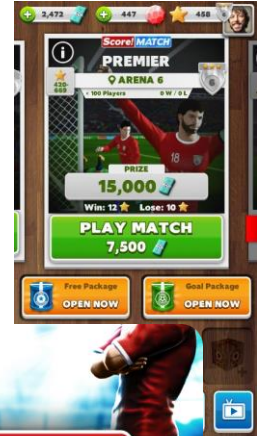


Dota 2 on PC
and macOS

AAA titles on Linux



...and Mobile



Plus....

Lineage 2 Revolution
 Heroes of Incredible Tales
 Dream League Soccer...



CODEMASTERS®



netmarble
 Games



Fortnite on Android!



FORTNITE

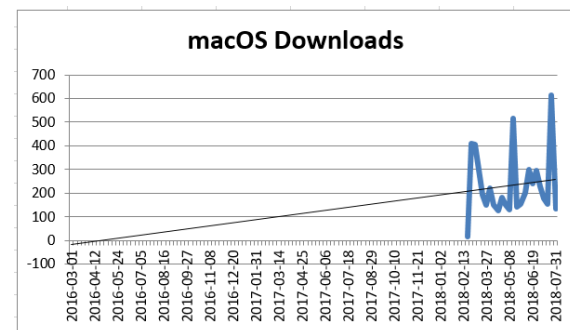
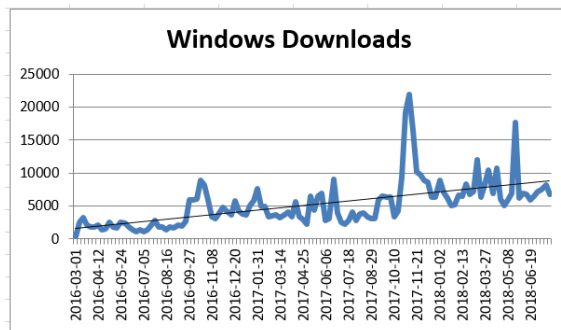
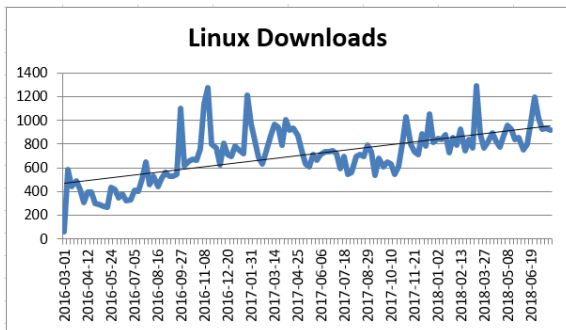
Vulkan®

Fortnite on Android uses Vulkan on select phones for optimal performance, including the best-performing Samsung - the Galaxy Note9

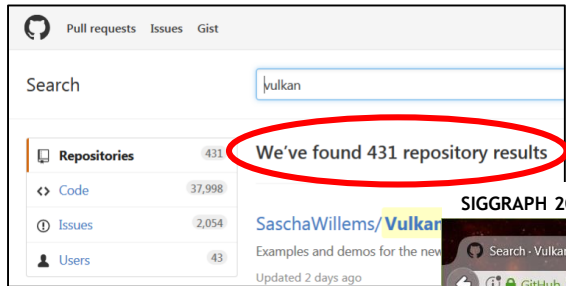
Vulkan Developer Activity - SDK and GitHub



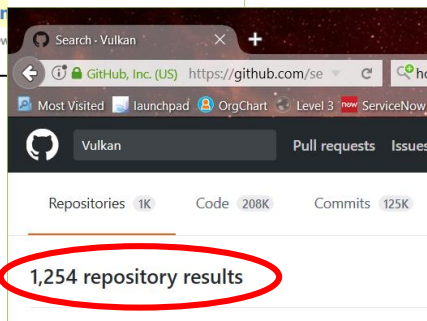
LunarG Vulkan SDK
Download rate increases every
year since launch
<http://vulkan.lunarg.com>



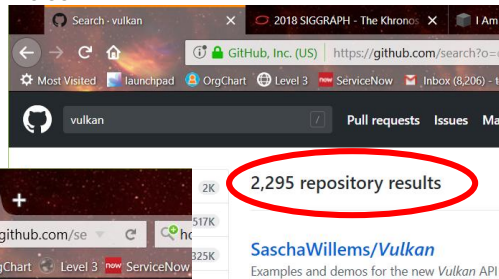
SIGGRAPH 2016



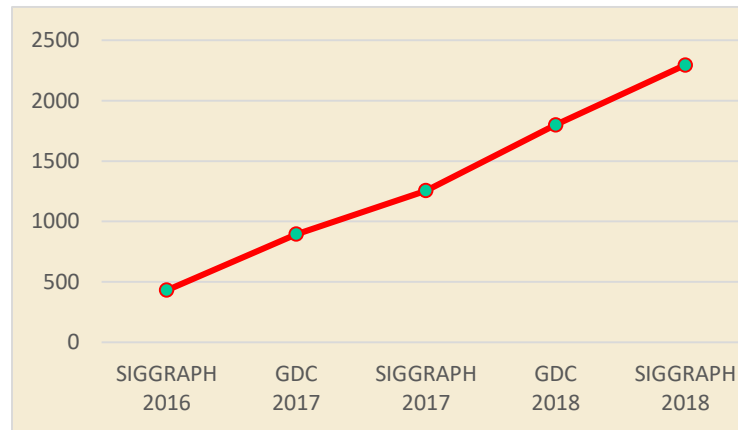
SIGGRAPH 2017



SIGGRAPH 2018

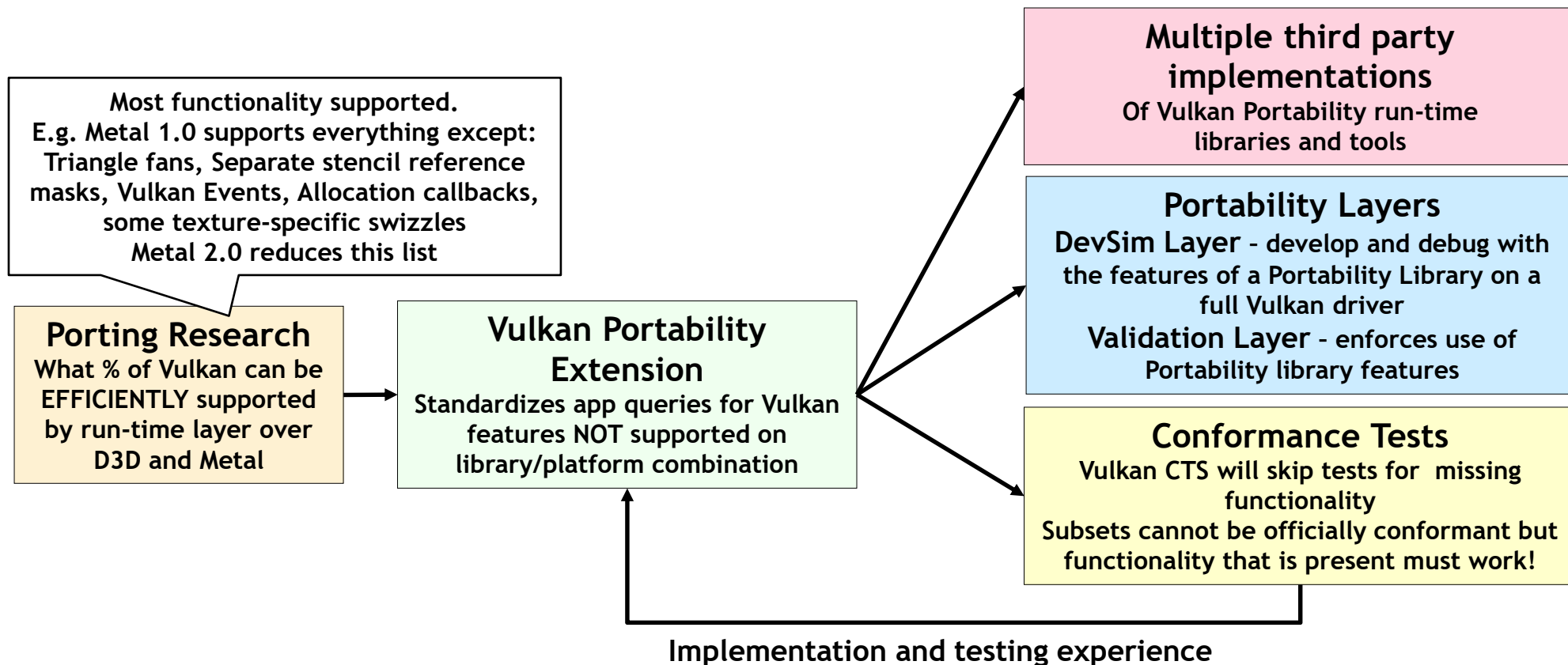


Vulkan Related GitHub Repos

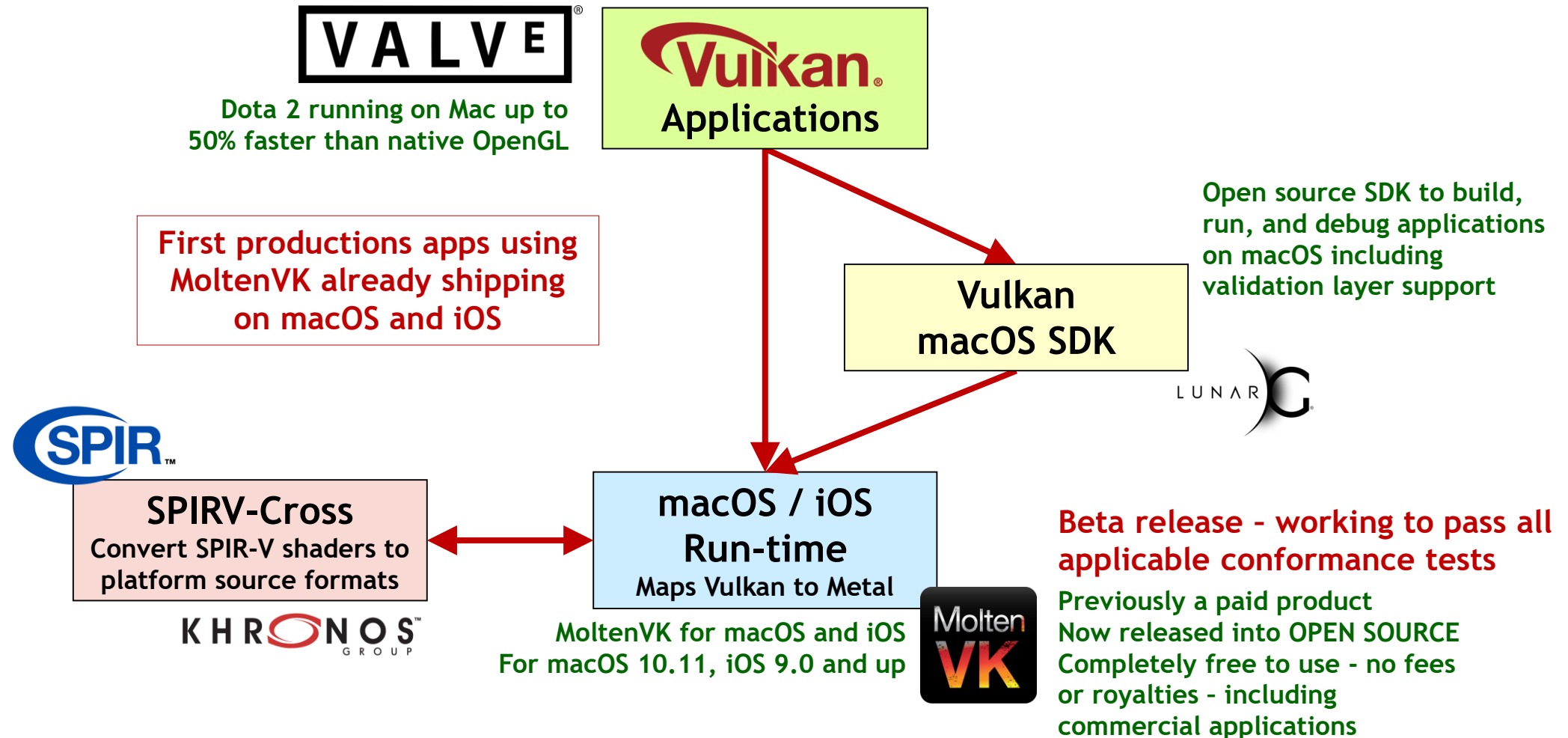


Vulkan Portability Initiative

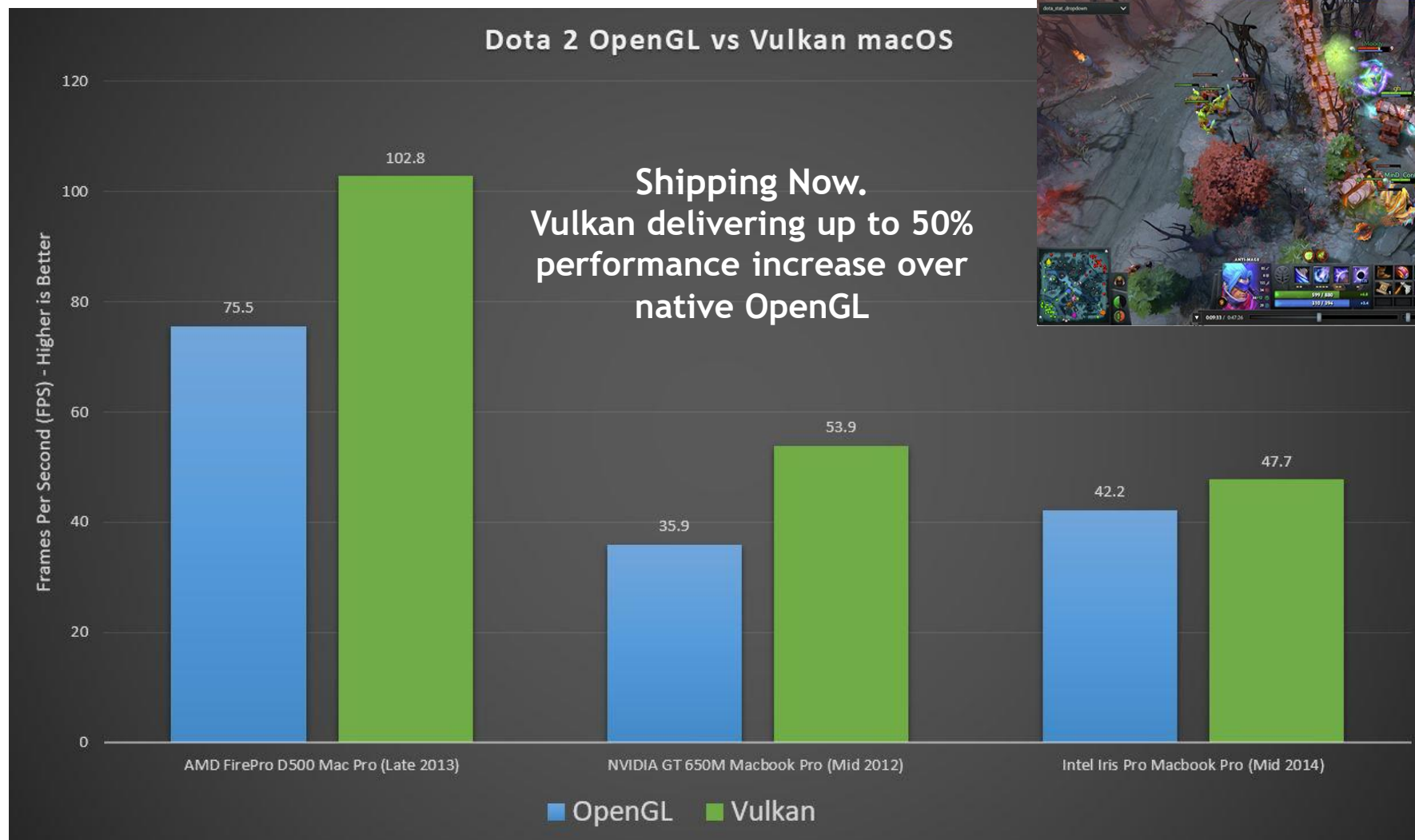
Enabling and accelerating the creation of tools and run-time libraries for Vulkan applications to run on platforms supporting only Metal or Direct3D



Bringing Vulkan Apps to Apple Platforms Today

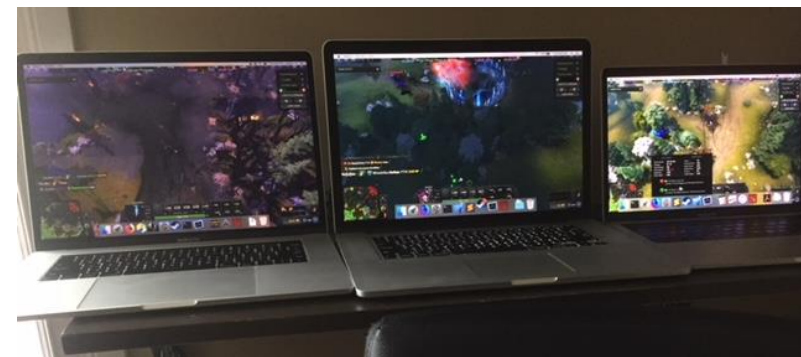


Valve - Vulkan Dota 2 on macOS



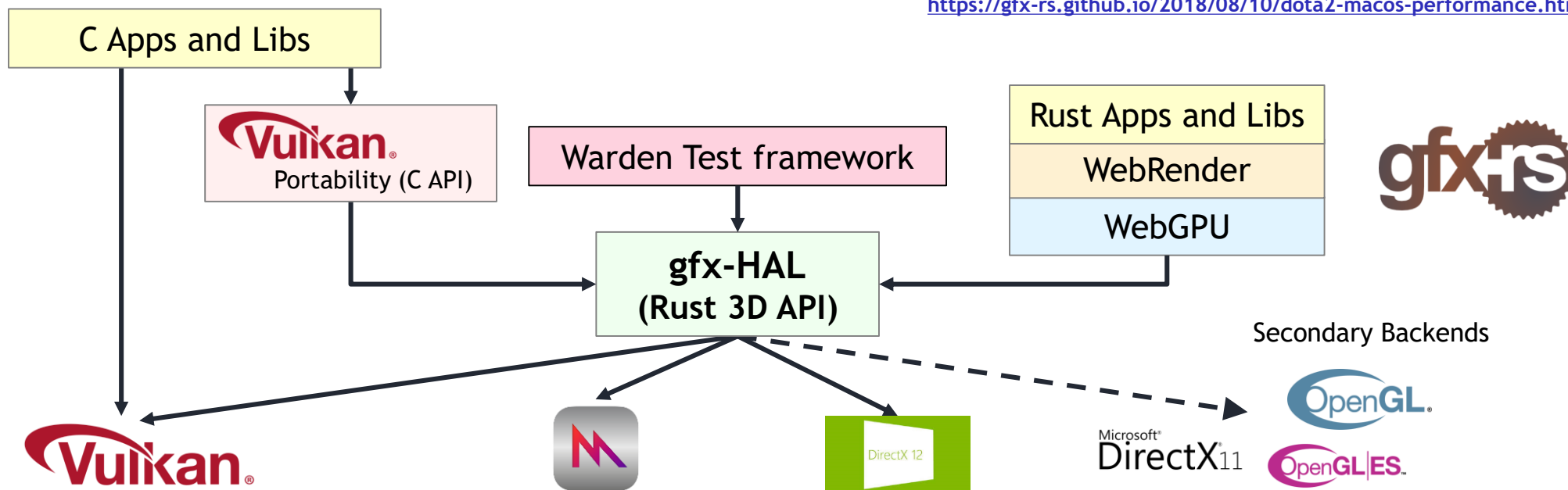
gfx-rs

- Vulkan Portability over D3D, Metal, and OpenGL
 - D3D layer useful for Vulkan on UWP platforms such as Windows 10 S, Polaris, Xbox One
 - <https://github.com/gfx-rs/gfx>
 - <https://github.com/gfx-rs/portability>



Efficiently running Dota 2 on Mac - working to increase conformance coverage

<https://gfx-rs.github.io/2018/08/10/dota2-macos-performance.html>



OpenGL and OpenGL ES



January 2018

OpenGL 4.6 conformance test suite
released in open source
Intel and NVIDIA released conformant
OpenGL 4.6 drivers

April 2018

OpenGL 4.6.0.1 CTS bugfix update
released in April



June 2018

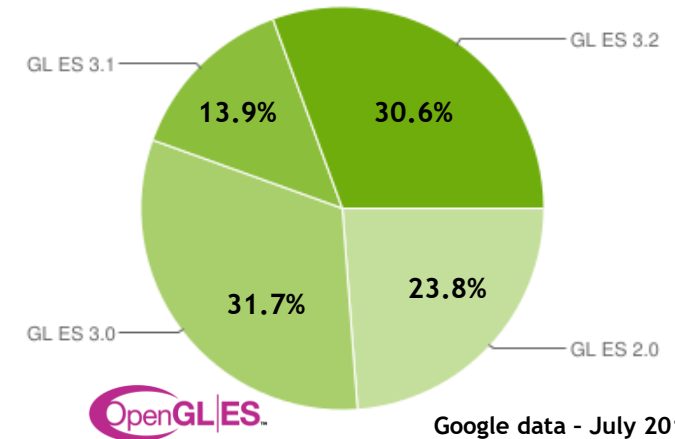
OpenGL ES CTS 3.2.5.0
released in open source
Raises the quality bar for OpenGL
3.2 implementations



**OpenGL ES still the most prevalent
3D API (billions of units!)**
More conformant products added
OpenGL ES 3.2 adoption increasing

Working Group Meetings Merged under one Chairperson for Improved Efficiency

GLSL and ESSL specs merged and migrated from LibreOffice to
AsciiDoctor to improve maintainability and reduce divergence
OpenGL 4.6, OpenGL ES 3.2, GLSL 4.60 and ESSL 3.20 specs June 2018
Lots of bug fixes - many leveraged from open GitHub projects



OpenGL ES and WebGL 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



Compute Shaders



Advanced Graphics

Tessellation and geometry shaders
ASTC Texture Compression
Floating point render targets
Debug and robustness for security



2007

OpenGL ES 2.0

2012

OpenGL ES 3.0

2014

OpenGL ES 3.1
Compute Shaders

2015

OpenGL ES 3.2



4 years

2011
WebGL 1.0

WebGL 2.0 Compute Context
Multiview extension

Work in Progress

5 years

March 2017
WebGL 2.0

Conformance Testing is vital for Cross-Platform Reliability

WebGL 2.0 conformance tests are very thorough 10x more tests than WebGL 1.0 tests

WebGL Momentum - WebGL 2.0 is Here!



FLASH & THE FUTURE OF INTERACTIVE CONTENT

POSTED BY ADOBE CORPORATE COMMUNICATIONS ON JULY 25, 2017

Subscribe

Adobe has long played a leadership role in advancing interactivity and creative content – from video, to games and more – on the web. Where we've seen a need to push content and interactivity forward, we've innovated to meet those needs. Where a format didn't exist, we invented one – such as with Flash and Shockwave. And over time, as the web evolved, these new formats were adopted by the community, in some cases formed the basis for open standards, and became an essential part of the web.

But as open standards like **HTML5, WebGL and WebAssembly** have matured over the past several years, most now provide many of the capabilities and functionalities that plugins pioneered and have become a viable alternative for content on the web. Over time, we've seen helper apps evolve to become plugins, and more recently, have seen many of these plugin capabilities get incorporated into open web standards. Today, most browser vendors are integrating capabilities once provided by plugins directly into browsers and deprecating plugins.

93.26% Globally

WebGL - 3D Canvas graphics - OTHER

Method of generating dynamic 3D graphics using JavaScript, accelerated through hardware

Current aligned	Usage relative	Date relative	Show all							
IE	Edge *	Firefox	Chrome	Safari	iOS Safari	Opera Mini *	Chrome for Android	UC Browser for Android	Samsung Internet	
	16	59	49		10.3					
	17	60	65		11.2				4	
11	18	61	66	11.1	11.3	all	66	11.8	6.2	
		62	67	12						
			68	TP						
			69							

<http://caniuse.com/#feat=webgl>

62.85% Globally

WebGL 2.0 - OTHER

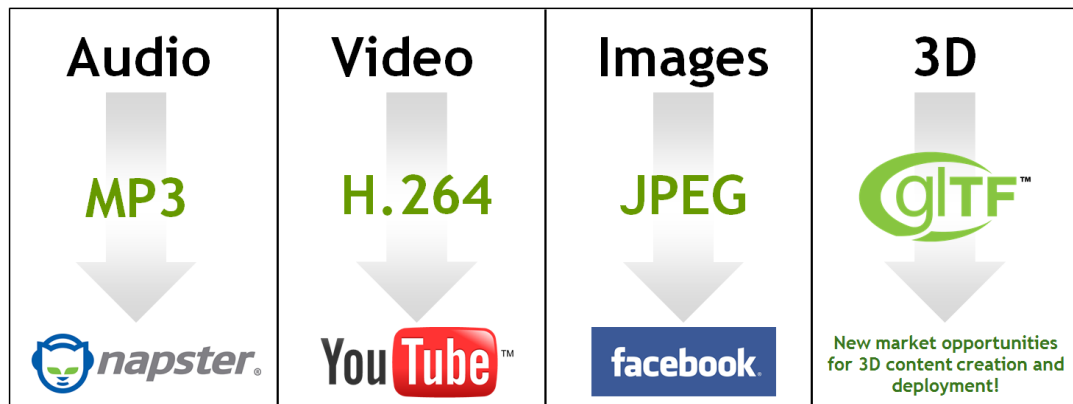
Next version of WebGL. Based on OpenGL ES 3.0.

Current aligned	Usage relative	Date relative	Show all							
IE	Edge *	Firefox	Chrome	Safari	iOS Safari	Opera Mini *	Chrome for Android	UC Browser for Android	Samsung Internet	
	16	59	49		10.3					
11	17	60	65	11.1	11.2				4	
	18	61	66	12	11.3	all	66	11.8	6.2	
		62	67	TP						
			68							
			69							

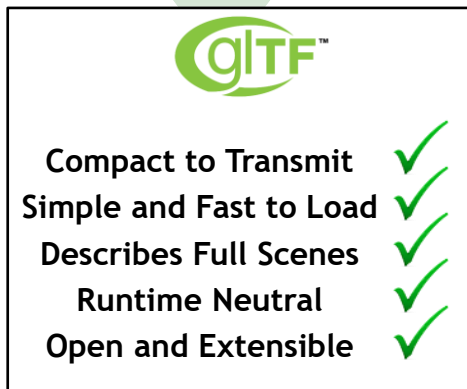


WebGL 2.0 brings Desktop-class graphics to the Web
The time to create a new class of Web-based 3D Apps is now!

glTF - Cross-Platform 3D Asset Transmission



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



Efficient, reliable transmission
Bring 3D assets into 1000s of apps
and engines - NOT an
Authoring Interchange Format



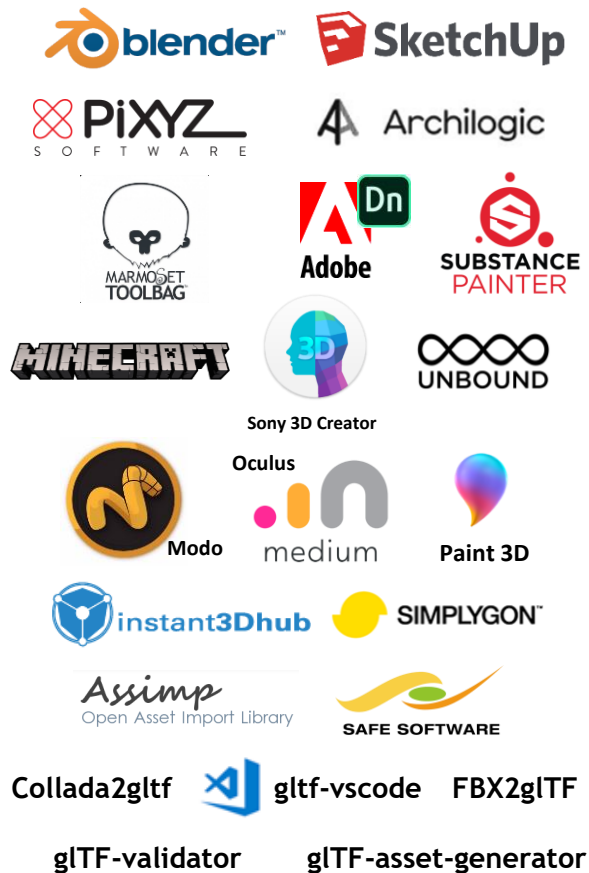
glTF 1.0 - December 2015
Primarily for WebGL
Uses GLSL for materials



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

glTF Ecosystem

Creation Tools



Repositories



Apps and Engines



Users

glTF Recent Highlights



Microsoft

Microsoft makes glTF files as pervasively usable as JPGs in Windows 10
Open sources entire glTF SDK! <https://github.com/Microsoft/glTF-SDK>

Adds glTF to StemCell - 60K+ 3D artists and 700K 3D models

<https://www.khronos.org/blog/turbosquid-adds-gltf-to-supported-formats-for-its-stemcell-initiative>

TURBOSQUID

facebook

Supports drag and drop of glTF models to your feed

<https://developers.facebook.com/blog/post/2018/02/20/3d-posts-facebook/>

Over 150K royalty-free glTF models

<https://sketchfab.com/features/gltf>



Sketchfab



Adobe

Dimension generates glTF for delivery of 3D marketing assets

https://www.khronos.org/assets/uploads/developers/library/2018-gdc-webgl-and-gltf/glTF-Adobe-Dimension-GDC_Mar18.pdf

Integrating glTF into HUBS Web VR Meeting Space

<https://www.roadtovr.com/mozillas-hubs-one-click-vr-meeting-space-ive-waiting/>

moz://a



3D Tiles community standard proposal references glTF for streaming 3D geospatial datasets

<http://www.opengeospatial.org/pressroom/pressreleases/2829>

Import of glTF into AR Core apps via the Google Sceneform Tools plugin

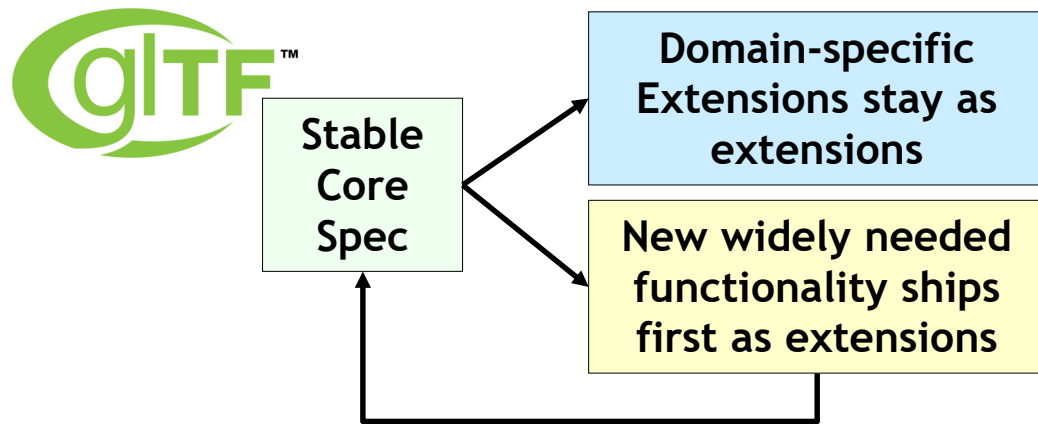
Draco Mesh Compression Technology Contributed as an extension

<https://www.khronos.org/news/press/khronos-announces-gltf-geometry-compression-extension-google-draco>

Google

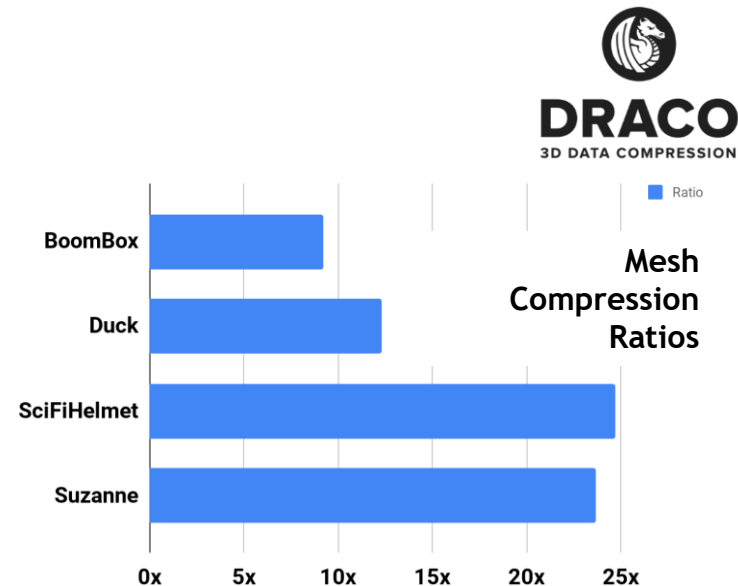
glTF Roadmap

- glTF manages its roadmap very carefully - complexity is the enemy
 - Mission #1: ensure widespread, consistent, reliable usage
- Rollout new functionality first as extensions: e.g. Draco Mesh Compression
 - Open source encoders and decoders are available
 - Extension is now shipping in more and more tools and engines
- New extensions...
 - Texture transform (for texture atlases) has shipped, Unlit Materials is close..

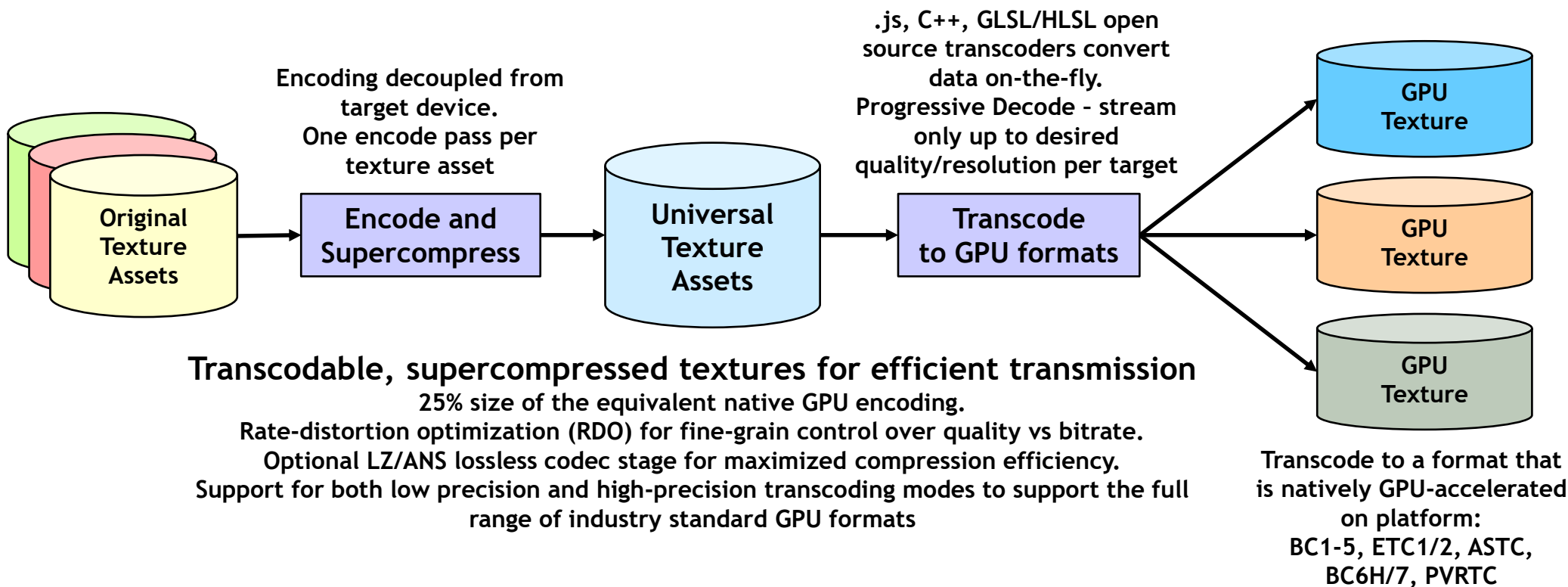


Integrate extensions into new core spec only when:

- 1) Widespread need is confirmed by the industry
- 2) Widespread reliable implementation is enabled (e.g. open source)



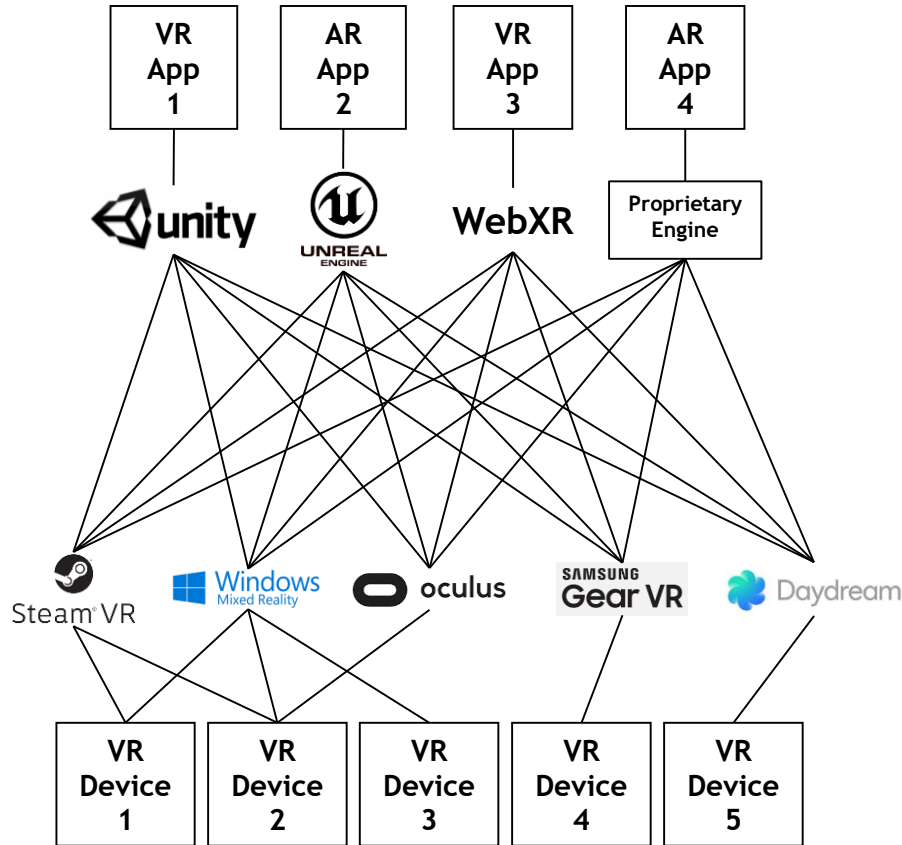
Texture Transmission Extension in Progress



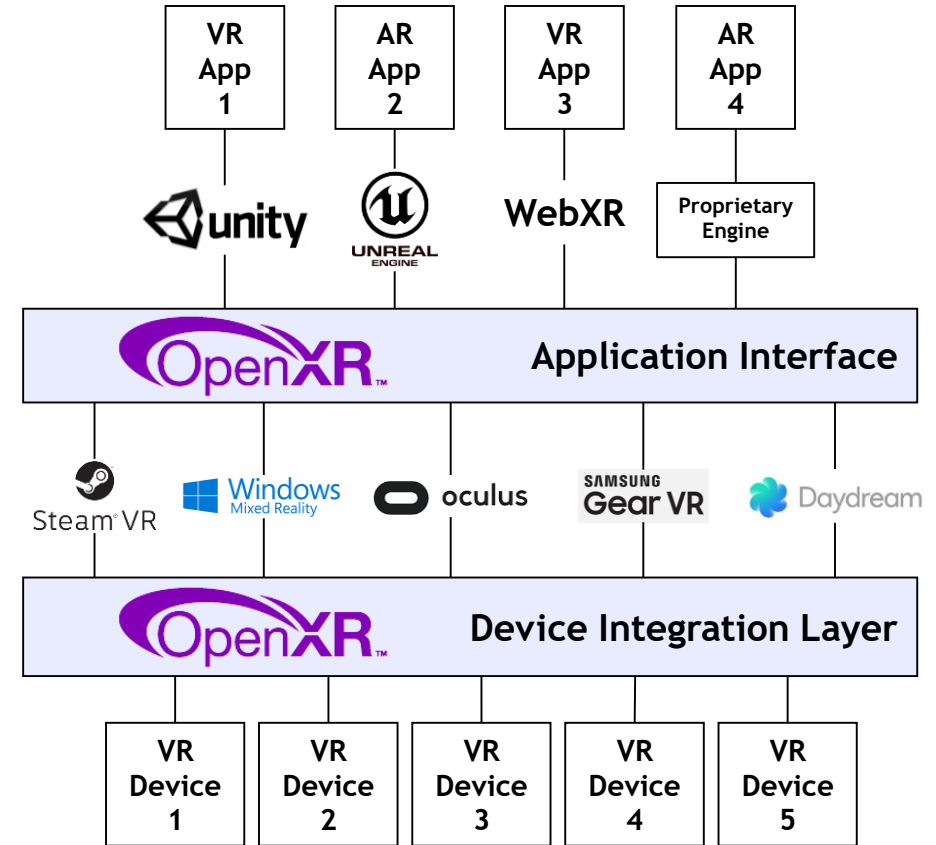
Extension in design - welcome industry feedback

<https://github.com/KhronosGroup/glTF-Texture-Transmission-Tools>

OpenXR - Solving VR/AR Fragmentation



Before OpenXR
XR Market
Fragmentation



After OpenXR
Wide interoperability of
XR apps and devices

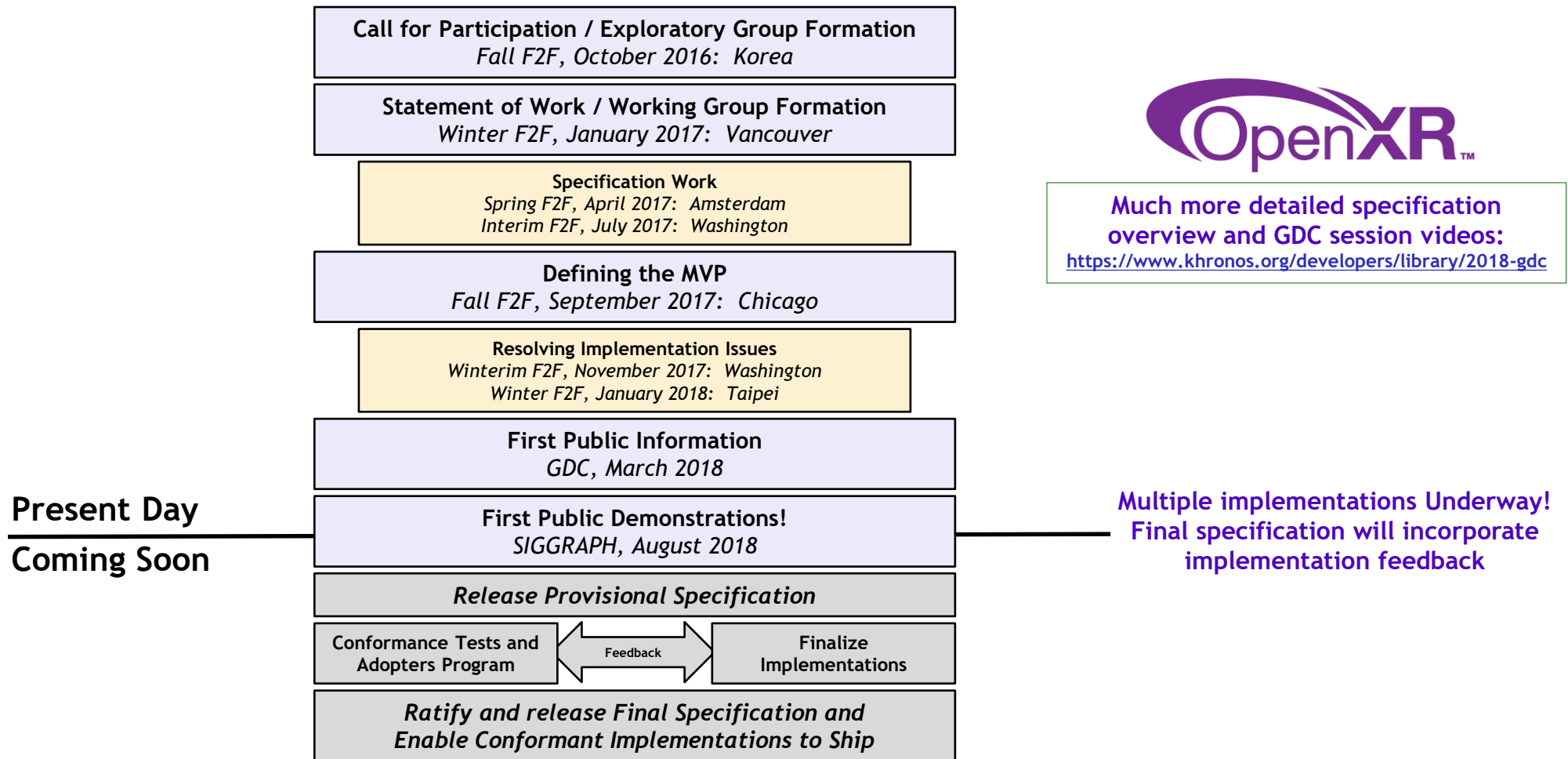
Companies Publicly Supporting OpenXR



OpenXR is a collaborative design

- 1) For cross-platform XR portability - VR in V1.0, then add AR
- 2) Integrating many lessons from proprietary 'first-generation' API designs

OpenXR Development Process



Epic 'Showdown' VR Demo at SIGGRAPH

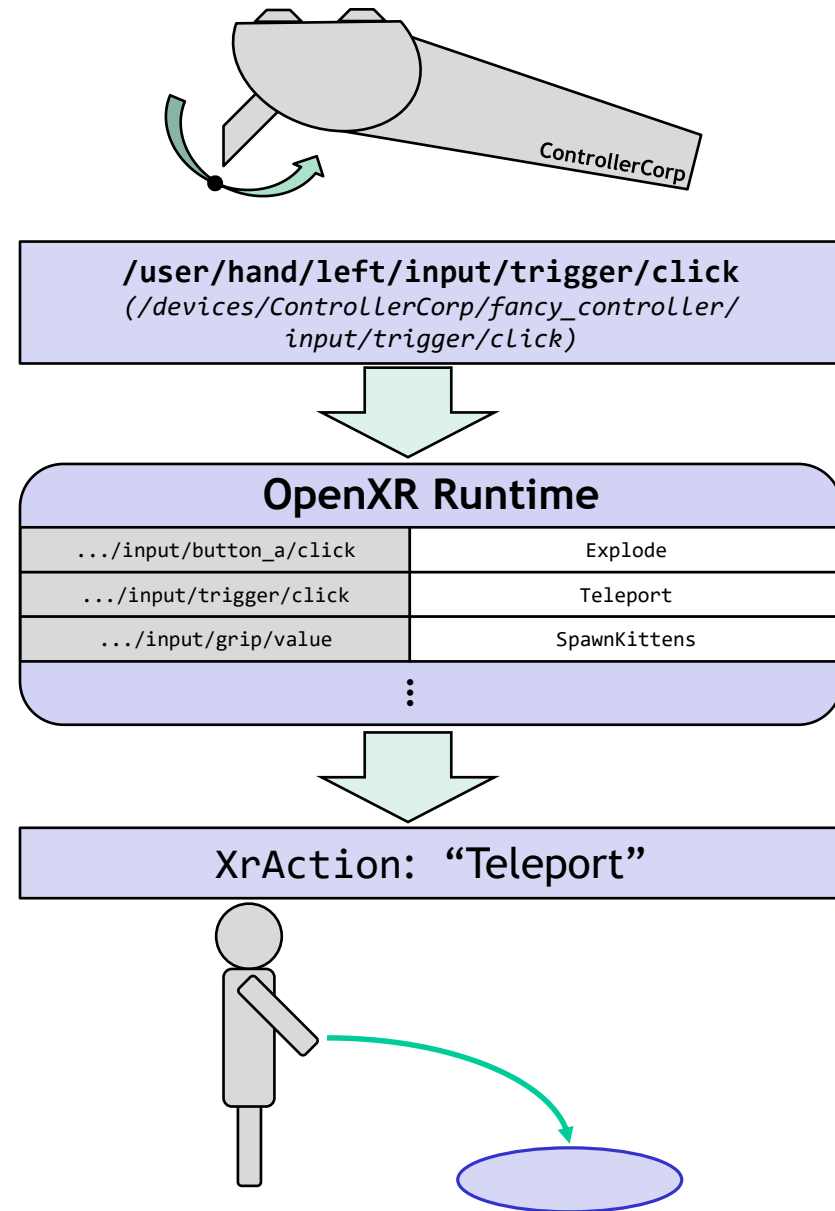


Demo runs portably across StarVR and Microsoft Windows Mixed Reality headsets through the OpenXR APIs via an Unreal Engine 4 plugin



Input and Haptics

- Input uses abstracted Input Actions
 - E.g. “Move,” “Jump,” “Teleport”
- Many advantages
 - Existing content can easily use new devices
 - Mix-and-match multiple input sources to create a unified UI
 - Easy optional feature support (e.g. eye and body tracking)
 - Future-proofing for innovation in input devices and form factors



OpenXR Viewport Configurations

- Applications can:
 - Query for runtime supported Viewport Configurations
 - Applications can then set the Viewport Configurations that they plan to use
 - Select and change their active configuration over the lifetime of the session




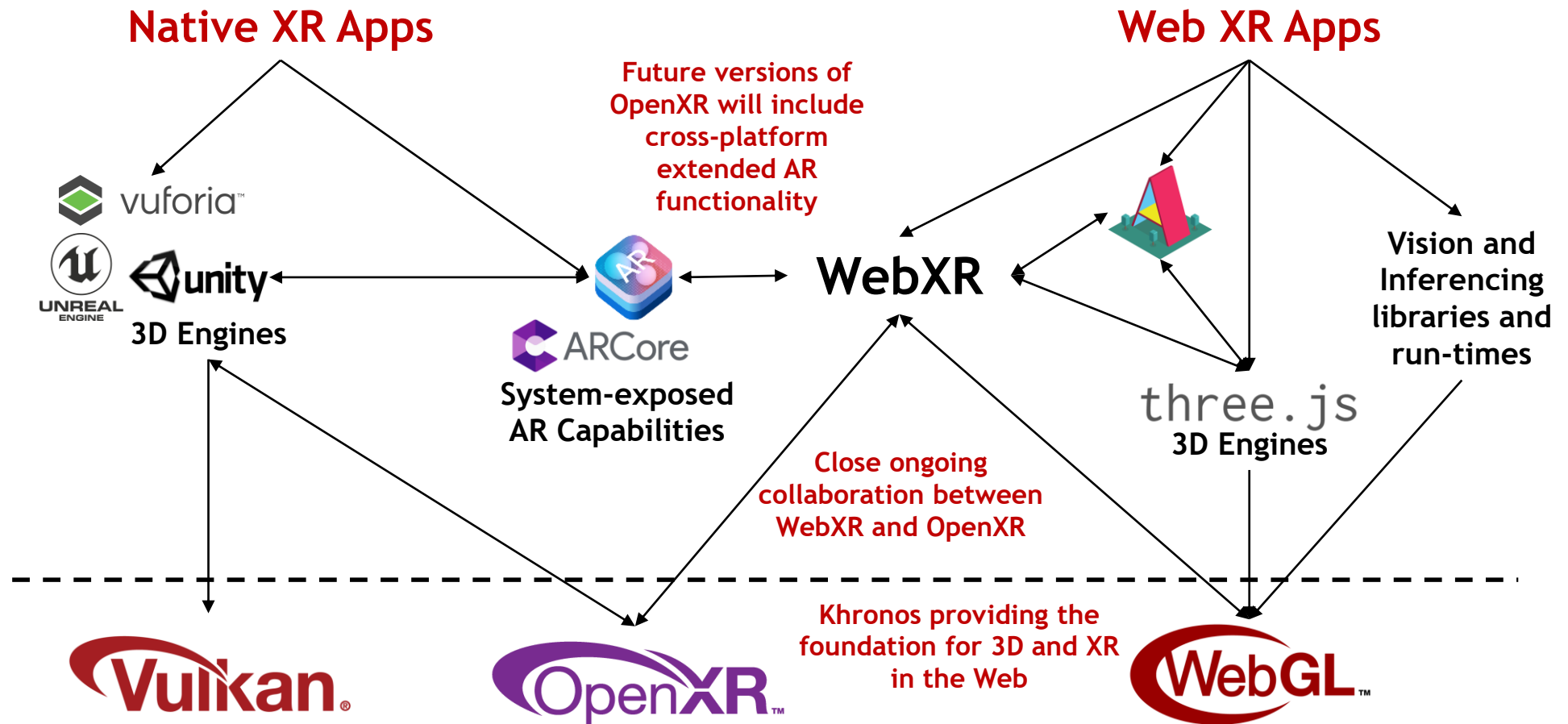
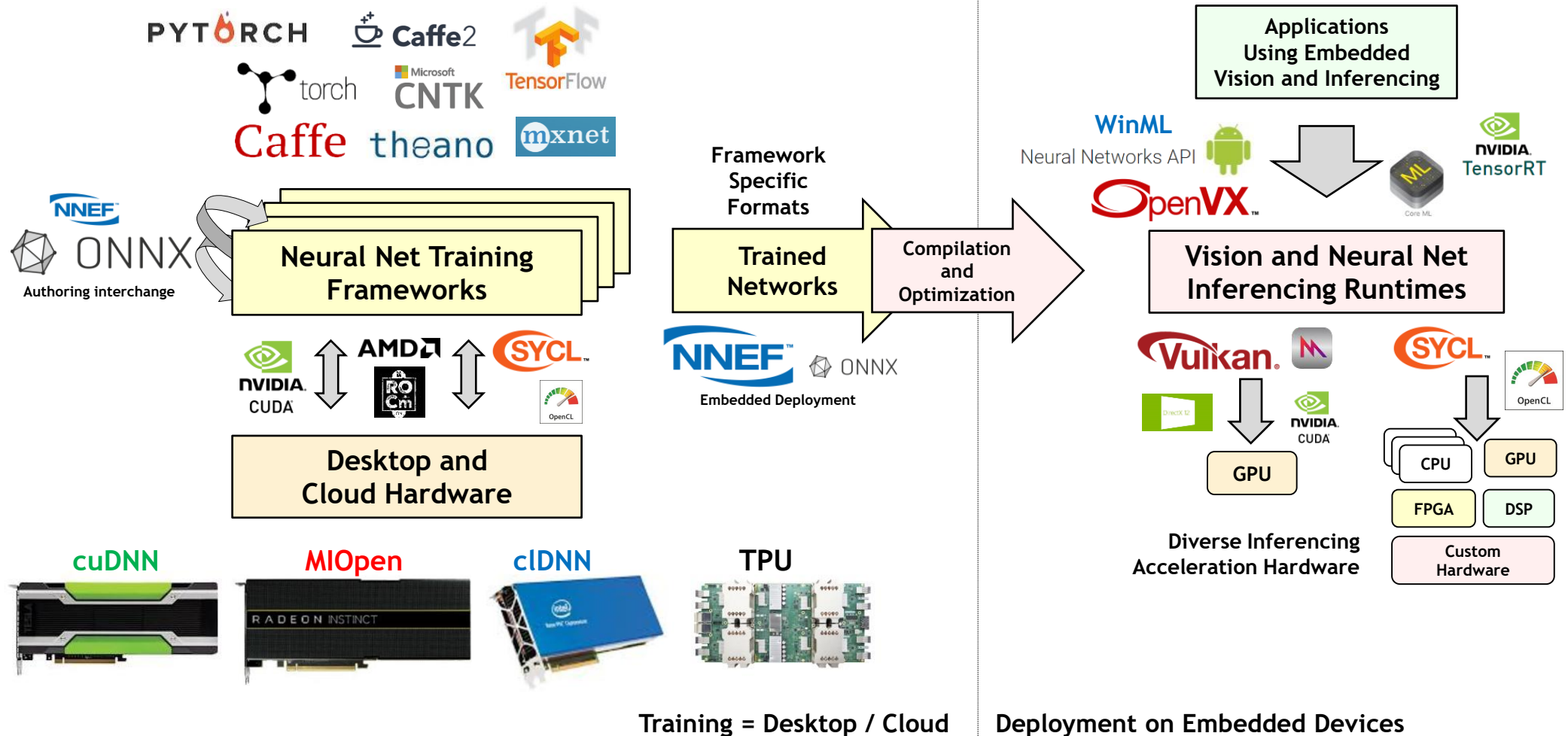
Camera Passthrough AR	Stereoscopic VR / AR	Projection CAVE-like
		
One Viewport	Two Viewports (one per eye)	Twelve Viewports (six per eye)
/viewport_configuration/ar_mono/magic_window	/viewport_configuration/vr/hmd	/viewport_configuration/vr_cube/cave_vr

Photo Credit: Dave Pape

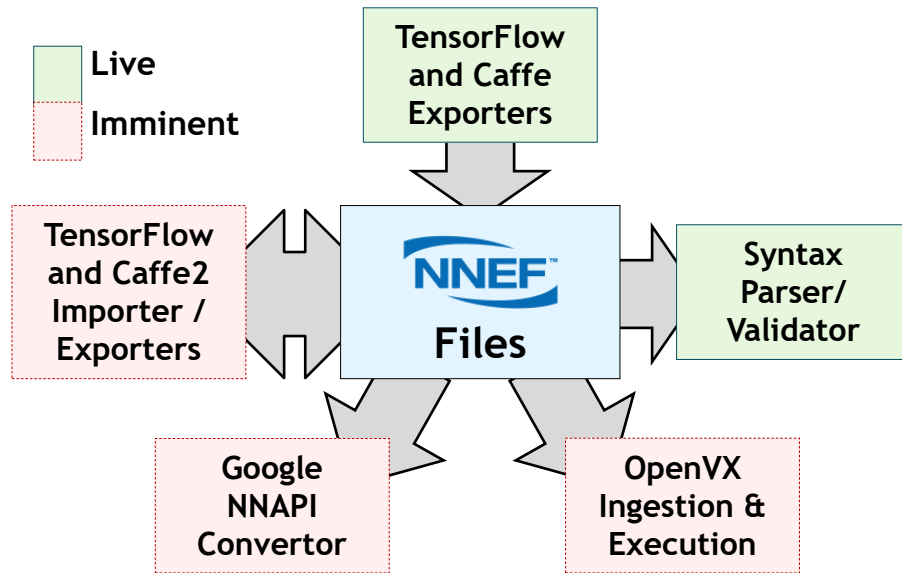
Layered XR Ecosystems



Neural Network Workflow



NNEF Ecosystem



NNEF open source projects hosted on
Khronos NNEF GitHub repository
Apache 2.0 license
<https://github.com/KhronosGroup/NNEF-Tools>

NNEF = Neural Network Exchange Format

NNEF V1.0 released at SIGGRAPH!!

After positive industry feedback on Provisional specification
released in December 2017

Comparing Neural Network Exchange Industry Initiatives



Defined Specification	Open Source Project
Stability for hardware deployment	Software stack flexibility
Multi-company Governance	Initiated by Facebook
Flexible Precision	32-bit Floating Point only
Flat and Compound Ops	Flat Ops Only

OpenVX

Wide range of vision hardware architectures
OpenVX provides a high-level Graph-based abstraction

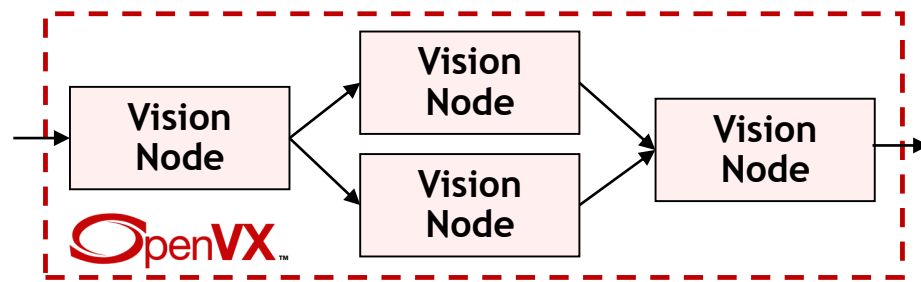
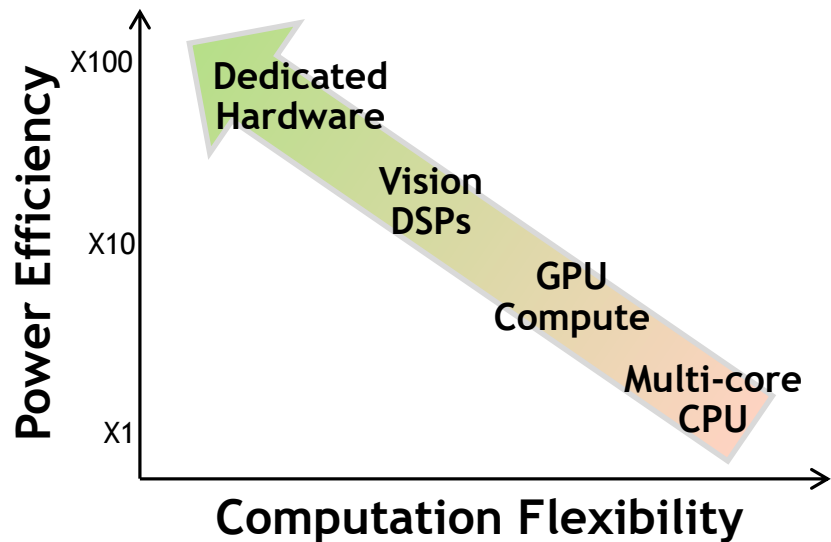
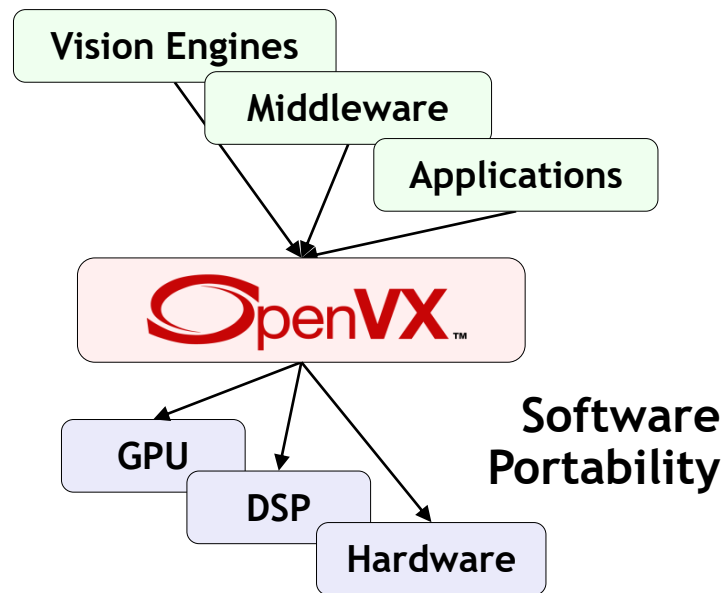
->

Enables Graph-level optimizations!

Can be implemented on almost any hardware or processor!

->

Portable, Efficient Vision Processing!



Vision Processing Graph

OpenVX Evolution



Conformant Implementations



OpenVX 1.0

Spec released October 2014

Conformant Implementations

cadence



Imagination



SYNOPSYS



TEXAS
INSTRUMENTS

New Functionality

Expanded Nodes Functionality
Enhanced Graph Framework

AMD OpenVX Tools

- Open source, highly optimized for x86 CPU and OpenCL for GPU
 - "Graph Optimizer"
 - Scripting for rapid prototyping, without re-compiling, at production performance levels
- <http://gpuopen.com/compute-product/amd-openvx/>

OpenVX 1.1

Spec released May 2016

New Functionality

Conditional node execution
Feature detection
Classification operators
Expanded imaging operations

Extensions

Neural Network Acceleration
Graph Save and Restore
16-bit image operation

Safety Critical

OpenVX 1.1 SC for
safety-certifiable systems

OpenVX 1.2

Spec released May 2017

Adopters Program November 2017

OpenVX

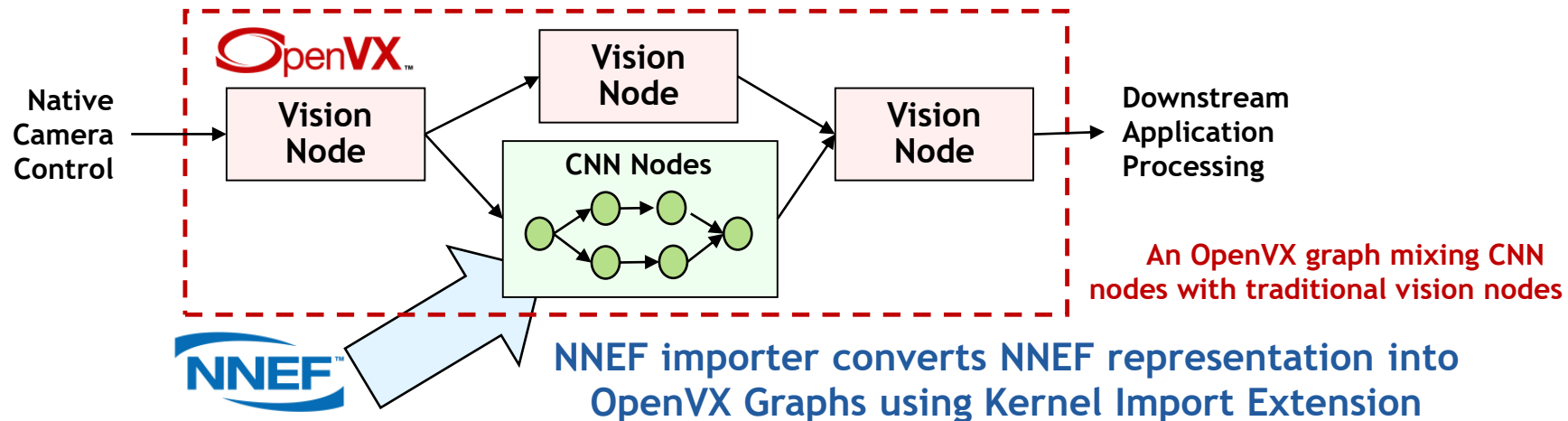
Roadmap under Development

NNEF Import

Programmable user
kernels with
accelerator offload

OpenVX NNEF Import

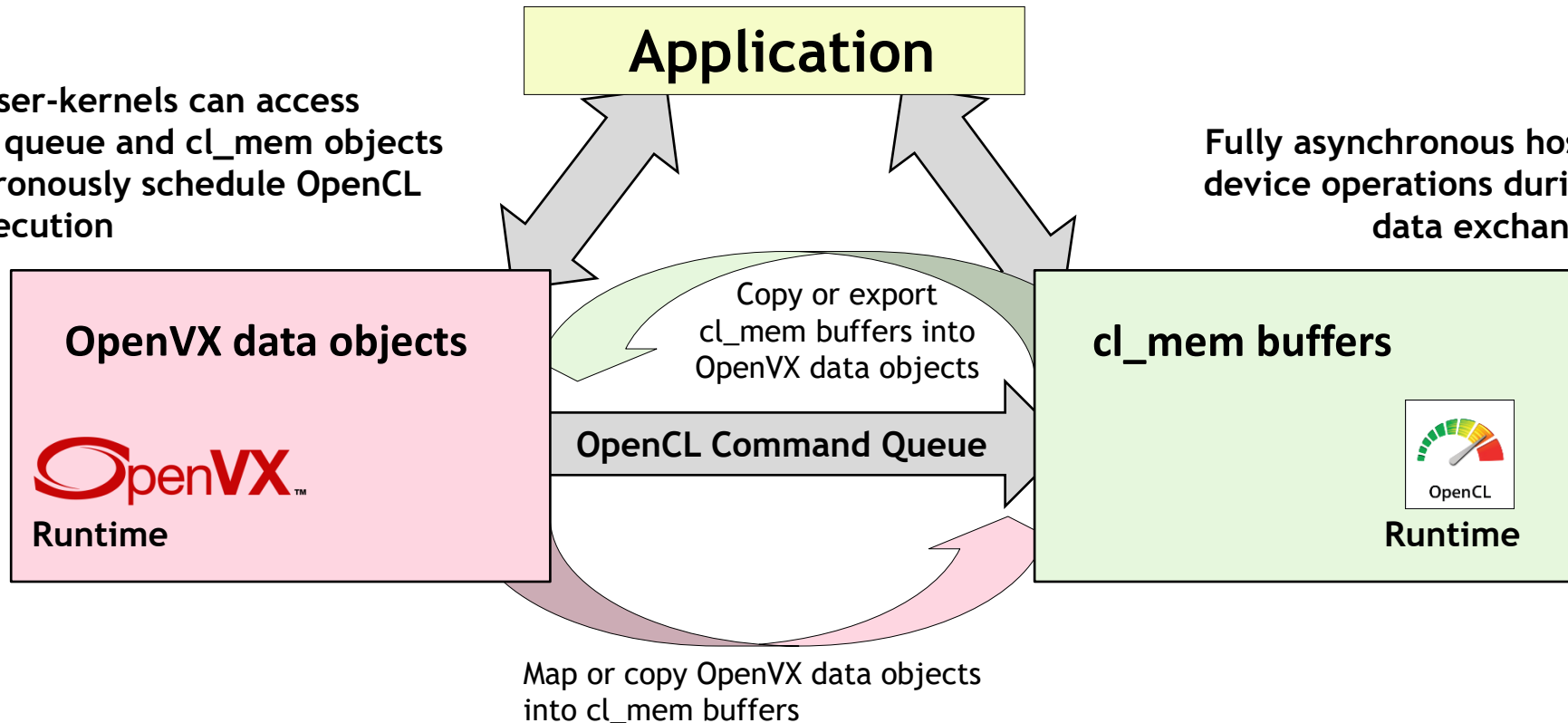
- Convolution Neural Network topologies can be represented as OpenVX graphs
 - Can also combine traditional vision and neural network operations
- OpenVX Neural Network Extension
 - Defines OpenVX nodes to represent many common NN layer types
 - Layer types include convolution, activation, pooling, fully-connected, soft-max
 - Defines multi-dimensional tensors objects to connect layers
- Kernel Import Extension
 - Enables loading of external program representations into OpenVX graphs



OpenVX / OpenCL Interop Extension

OpenVX user-kernels can access command queue and cl_mem objects to asynchronously schedule OpenCL kernel execution

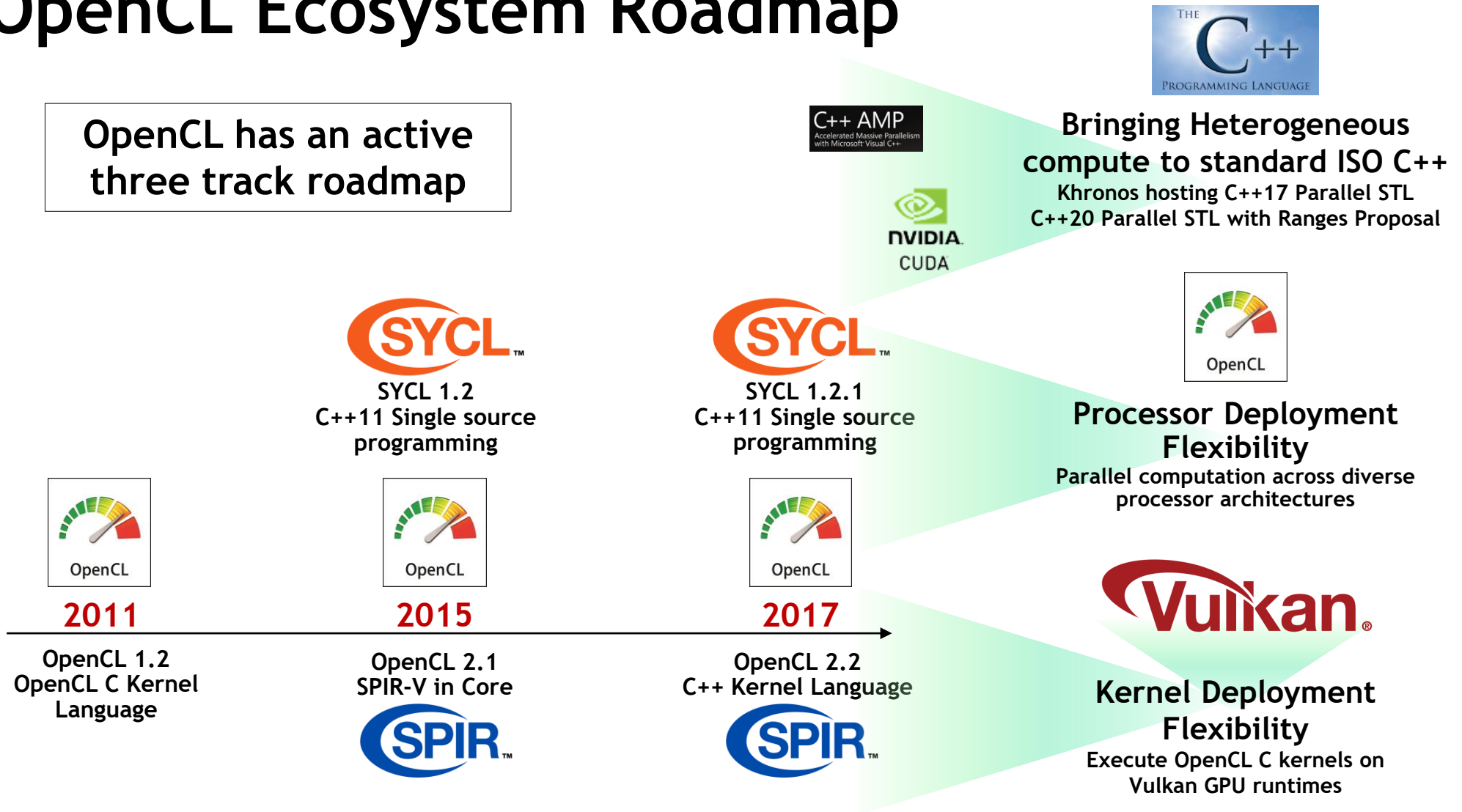
Fully asynchronous host-device operations during data exchange



Enables custom OpenCL acceleration to be used within OpenVX User Kernels

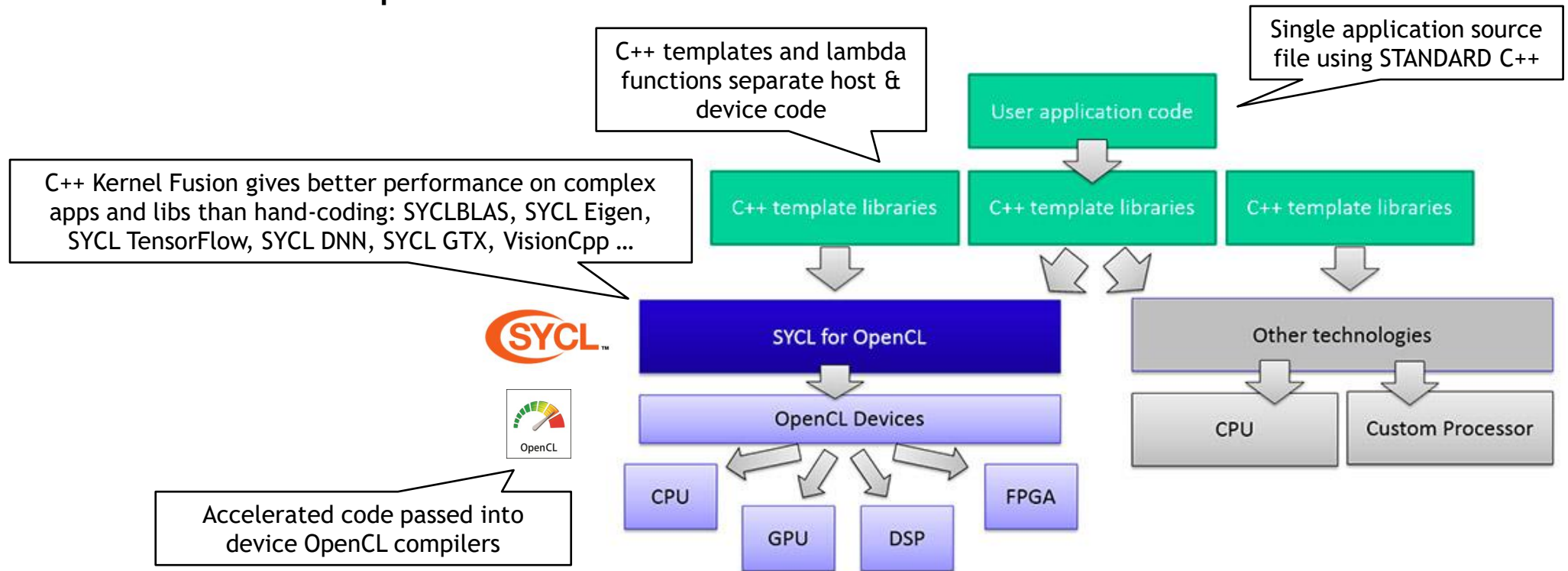
OpenCL Ecosystem Roadmap

OpenCL has an active
three track roadmap



SYCL Single Source C++ Parallel Programming

- SYCL 1.2.1 Adopters Program released in July 2018 with open source conformance tests
 - <https://www.khronos.org/news/press/khronos-releases-conformance-test-suite-for-sycl-1.2.1>
- Multiple Implementations shipping: triSYCL, ComputeCpp, ComputeCpp SDK
 - <http://sycl.tech>
- SYCL 2.2 Provisional Specification Released



Bringing OpenCL Compute to Vulkan

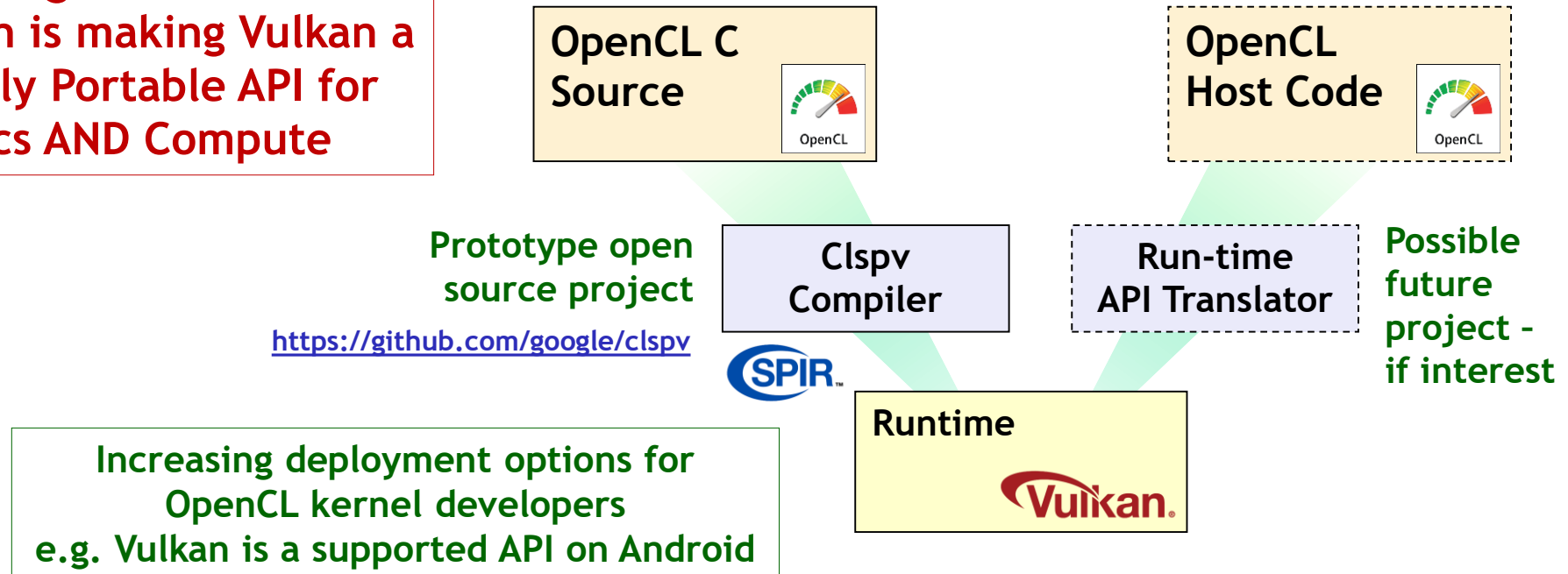


Adobe



- Experimental Clspv Compiler from Google, Adobe and Codeplay
 - Compiles OpenCL C to Vulkan's SPIR-V execution environment
Successfully tested on over 200K lines of Adobe OpenCL C production code
 - Open source - tracks top-of-tree LLVM and clang, not a fork

Layering and cross-compilation is making Vulkan a Universally Portable API for Graphics AND Compute



Refining clspv with Diverse Workloads

Public test kernel repository so developers can upload kernels to be used in long-term perf/regression testing
<https://github.com/KhronosGroup/OpenCL-Sample-Kernels>

Interesting domains to explore include existing OpenCL compute libraries - including vision and inferencing

Vulkan is already expanding its compute model e.g. 16-bit storage, Variable Pointers, Subgroups. Compact memory types and operations coming

Compile diverse OpenCL C kernel workloads



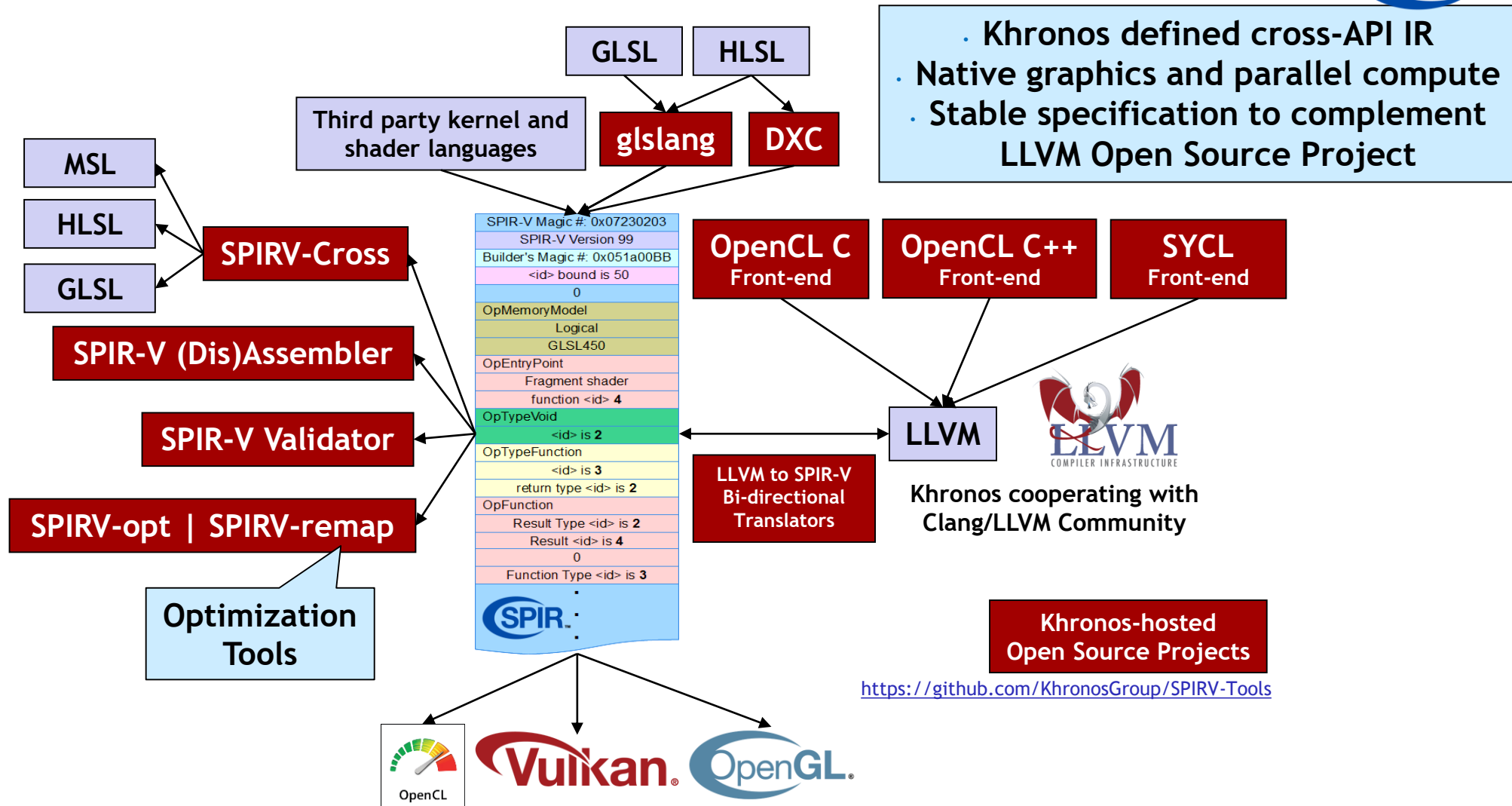
Efficient mapping to Vulkan SPIR-V?

Updates to open source achieve efficient mapping?

Propose updates to Vulkan programming model

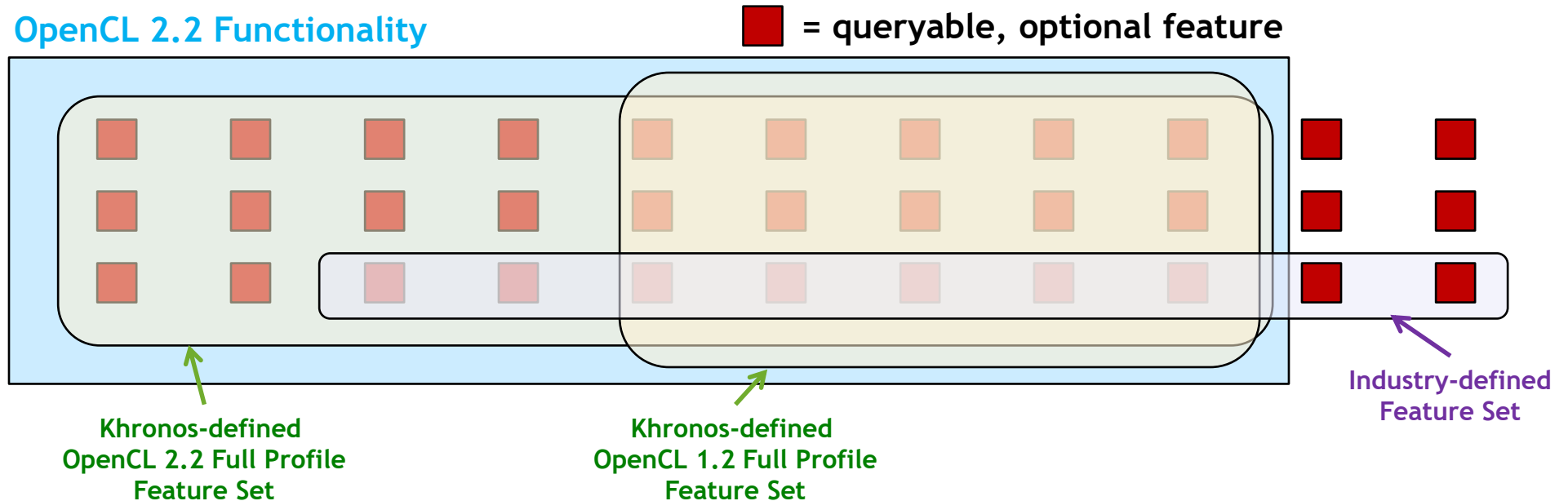


SPIR-V Ecosystem



OpenCL Next - Feature Set Flexibility

- Defining OpenCL features that become optional for enhanced deployment flexibility
 - API and language features e.g. floating point precisions
- Feature Sets avoid fragmentation
 - Defined to suit specific markets - e.g. desktop, embedded vision and inferencing
- Implementations are conformant if fully support feature set functionality



Khronos Education Forum

- **Supporting educators to teach Khronos technologies**
 - A common platform on which to openly share and discuss course materials
 - Khronos will manage an Open Educational Resource hub
 - <https://www.khronos.org/education>
- **Feedback on materials from the related Khronos Working Groups**
 - Direct contact with the designers of the standards
- **Any educator is welcome to get involved!**
 - Just send an email to education@khronos.org
 - Name, institution, and the Khronos standards you want to teach





Come Back at **5:30** for the
NETWORKING RECEPTION

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