OpenCL 2.1 and SPIR-V 1.0 Launch

November 2015

OpenCL 2.1 and SPIR-V 1.0 Launch

- **OpenCL 2.1 and SPIR-V 1.0 publicly launched**
  - Supercomputing 2015, Austin, Monday 16th November
- **OpenCL 2.1 brings SPIR-V 1.0 ingestion into core**
  - www.khronos.org/opencl/
- **SPIR-V 1.0 intermediate language with native support for parallel compute**
  - www.khronos.org/spir/
- **SPIR-V 1.0 enables front-end language and framework innovation**
  - Khronos releasing SPIR-V open source tools
  - SPIR-V will also be used in upcoming Vulkan graphics API

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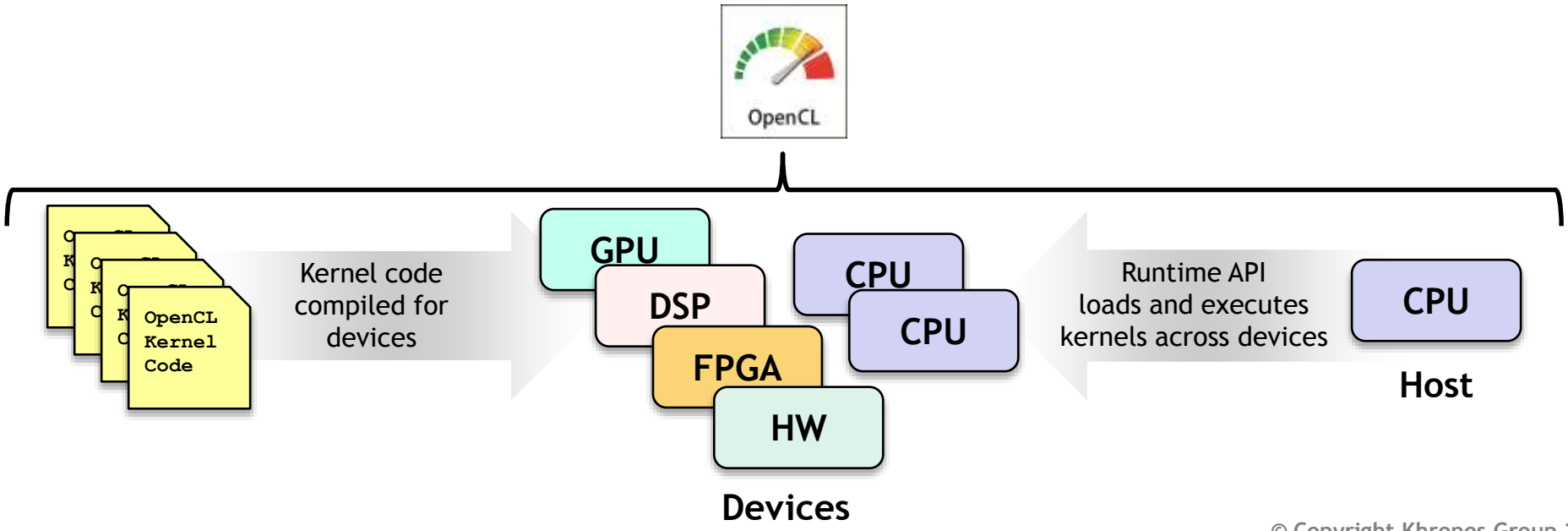
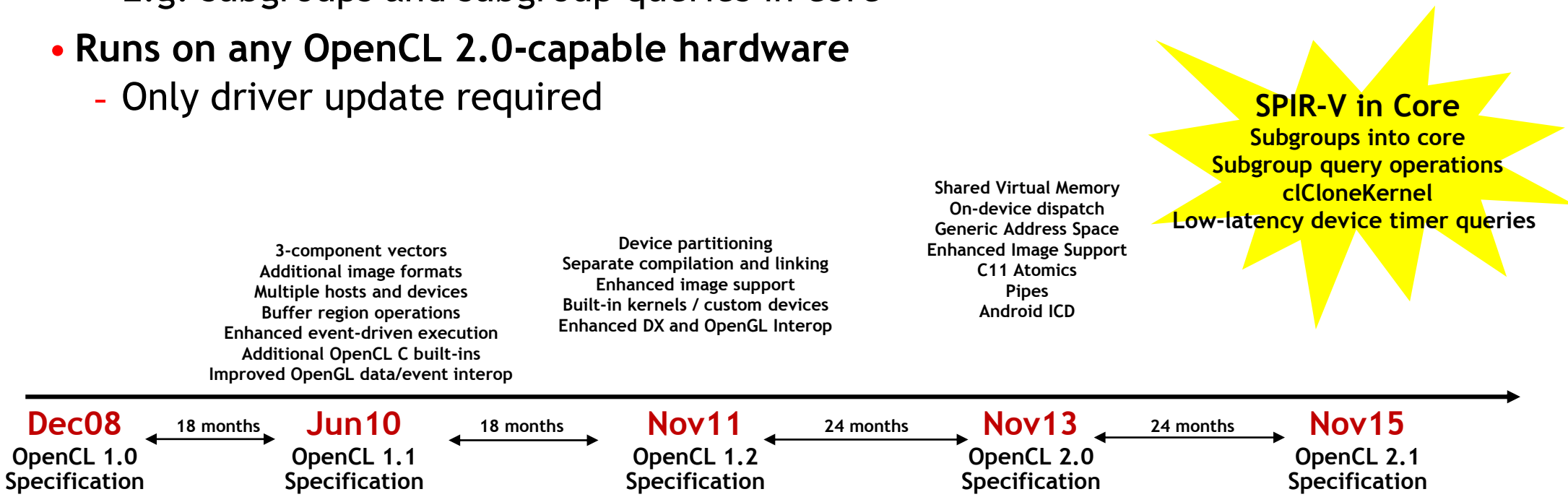
OpenCL – Portable Heterogeneous Computing

- **OpenCL = Two APIs and Two Kernel languages**
  - C Platform Layer API to query, select and initialize compute devices
  - OpenCL C and (soon) OpenCL C++ kernel languages to write parallel code
  - C Runtime API to build and execute kernels across multiple devices
- **One code tree can be executed on CPUs, GPUs, DSPs, FPGA and hardware**
  - Dynamically balance work across available processors



OpenCL 2.1 Released - November 2015

- **Support for the SPIR-V 1.0 intermediate language in core**
  - E.g. SPIR-V used to ingest from diverse language front-ends
  - OpenCL C ingestion still supported to preserve kernel code investment
- **OpenCL API updates**
  - E.g. subgroups and subgroup queries in core
- **Runs on any OpenCL 2.0-capable hardware**
  - Only driver update required



OpenCL 2.1 API Enhancements

- **clCreateProgramWithIL**
  - SPIR-V support built-in to the runtime
- **Subgroup query operations**
  - Subgroups expose hardware threading in the core feature set
- **clCloneKernel enables copying of kernel objects and state**
  - Safe implementation of copy constructors in wrapper classes
- **Low-latency device timer queries**
  - Support alignment of profiling between device and host code
- **Priority and throttle hint extensions for queues**
  - Specify execution priority on a per-queue basis
- **Zero-size enqueue**
  - Zero-sized dispatches are valid from the host

OpenCL C++ - Finalization Imminent

- **The OpenCL C++ kernel language is a static subset of C++14**
  - Frees developers from low-level coding details without sacrificing performance
- **C++14 features removed from OpenCL C++ for parallel programming**
  - Exceptions, Allocate/Release memory, Virtual functions and abstract classes Function pointers, Recursion and goto
- **Classes, lambda functions, templates, operator overloading etc..**
  - Fast and elegant sharable code - reusable device libraries and containers
  - Templates enable meta-programming for highly adaptive software
  - Lambdas used to implement nested/dynamic parallelism
- **C++11-based standard library optimized for data-parallel programming**
  - Atomics, meta-programming & type traits, math functions…
  - Plus new library features: Work-item & Work-group functions, Dynamic parallelism, Image & Pipe functions…

Highly adaptive parallel software that delivers tuned performance across diverse platforms

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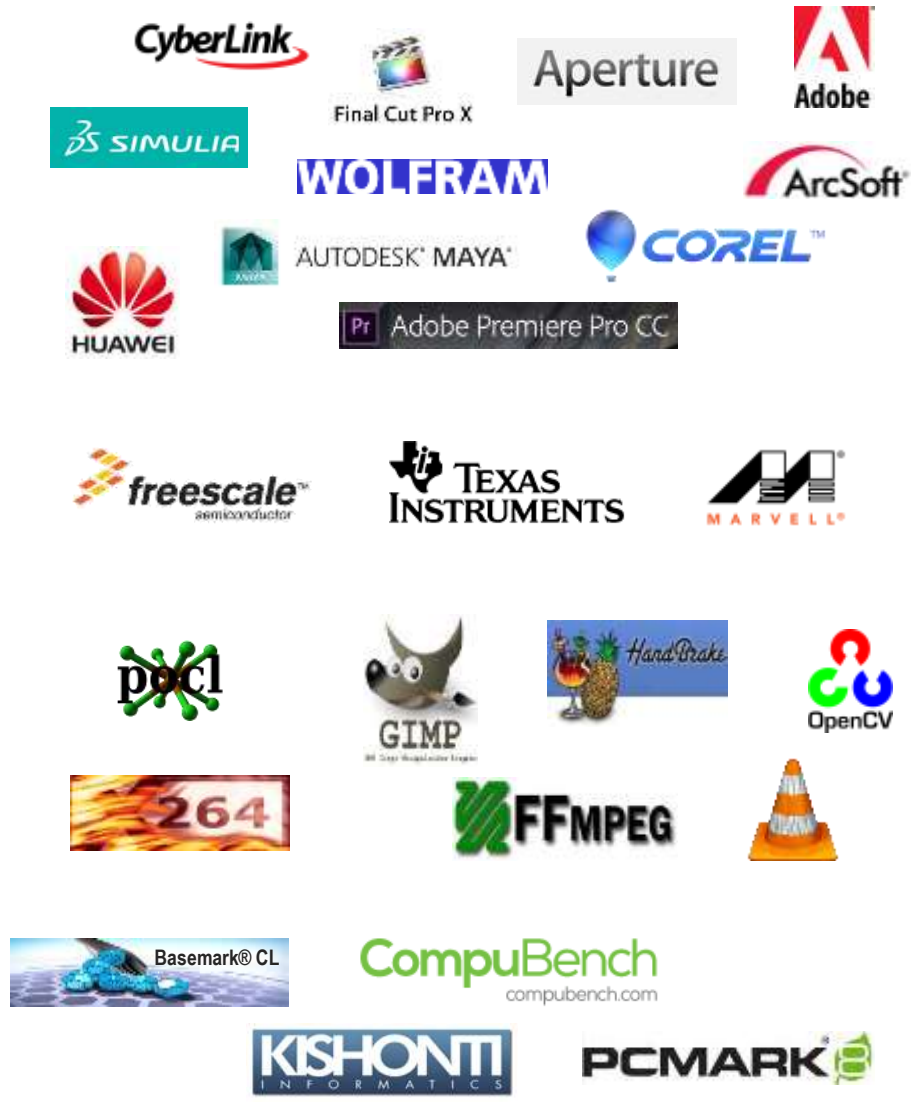
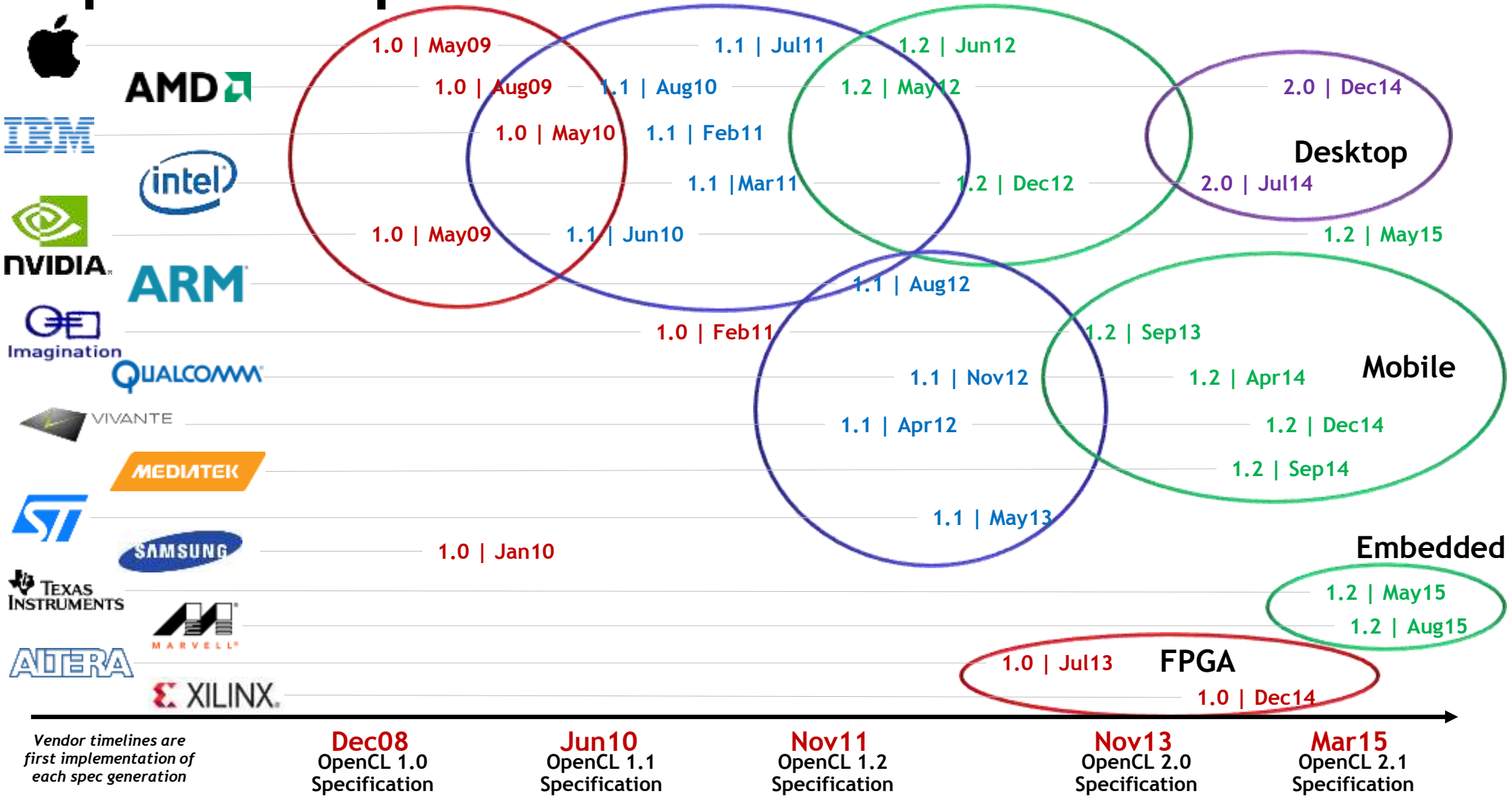
OpenCL Accelerated Apps

- **Desktop Apps**
  - Imaging, video, vision
  - Design simulation
  - Neural net training and acceleration
- **Embedded**
  - Camera and photography pipelines
  - Embedded neural net acceleration
- **Over 2000 open source projects use OpenCL**
  - Sourceforge, Github, Google Code etc.
  - OpenCL implementations - Beignet, pocl
  - Imaging, video, vision, compression, crypto
- **Benchmarks**
  - PCMark 8 – video chat and edit
  - Basemark CL, CompuBench Desktop

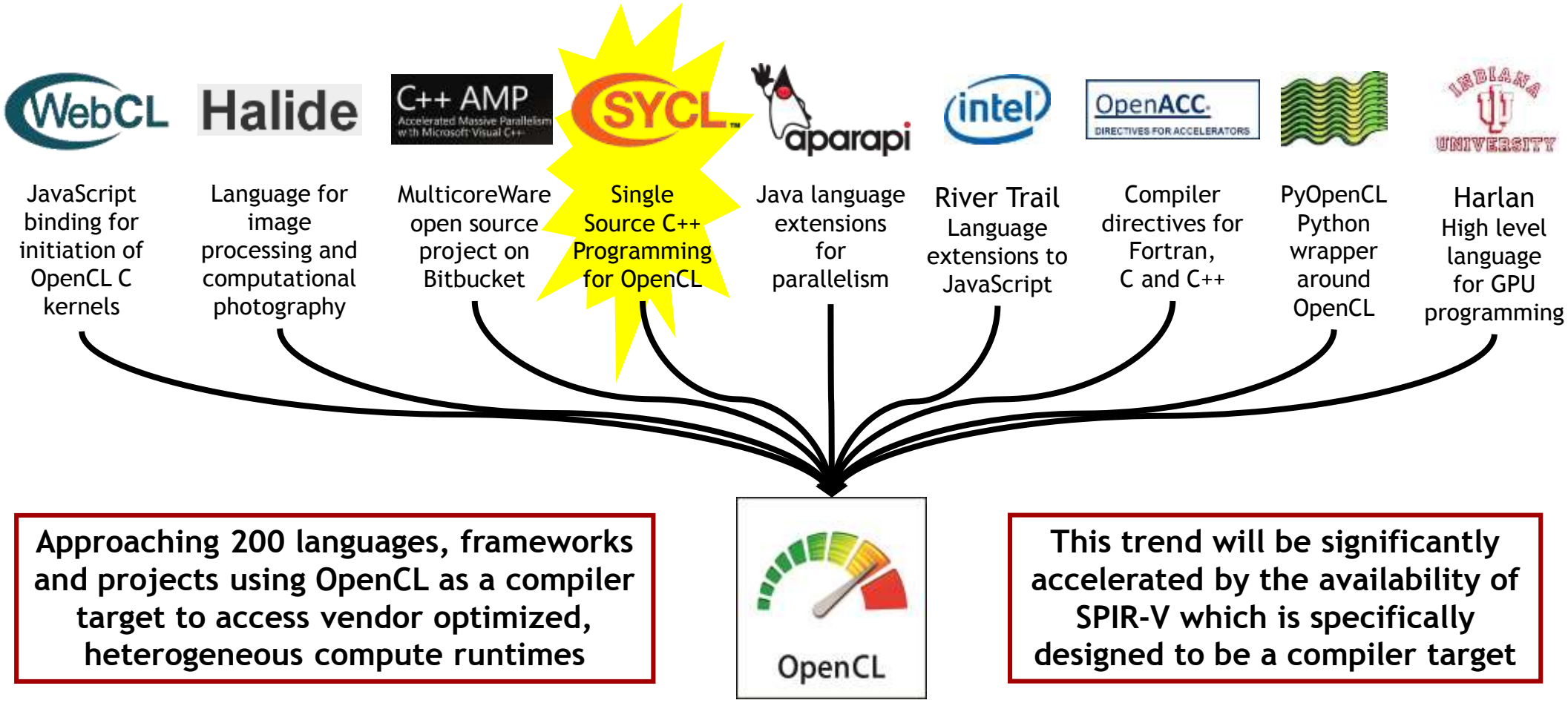
https://www.khronos.org/opencl/resources/opencl-applications-using-opencl



OpenCL Implementations



OpenCL as Parallel Language Backend



Approaching 200 languages, frameworks and projects using OpenCL as a compiler target to access vendor optimized, heterogeneous compute runtimes

This trend will be significantly accelerated by the availability of SPIR-V which is specifically designed to be a compiler target

SPIR-V Transforms the Language Ecosystem

- **First multi-API, intermediate language for parallel compute and graphics**
  - Native representation for Vulkan shader and OpenCL kernel source languages
  - https://www.khronos.org/registry/spir-v/papers/WhitePaper.pdf
- **Cross vendor intermediate representation**
  - Language front-ends can easily access multiple hardware run-times
  - Acceleration hardware can leverage multiple language front-ends
  - Encourages tools for program analysis and optimization in SPIR form

Multiple Developer Advantages

Same front-end compiler for multiple platforms
Reduces runtime kernel compilation time
Don't have to ship shader/kernel source code
Drivers are simpler and more reliable

Evolution of SPIR Family

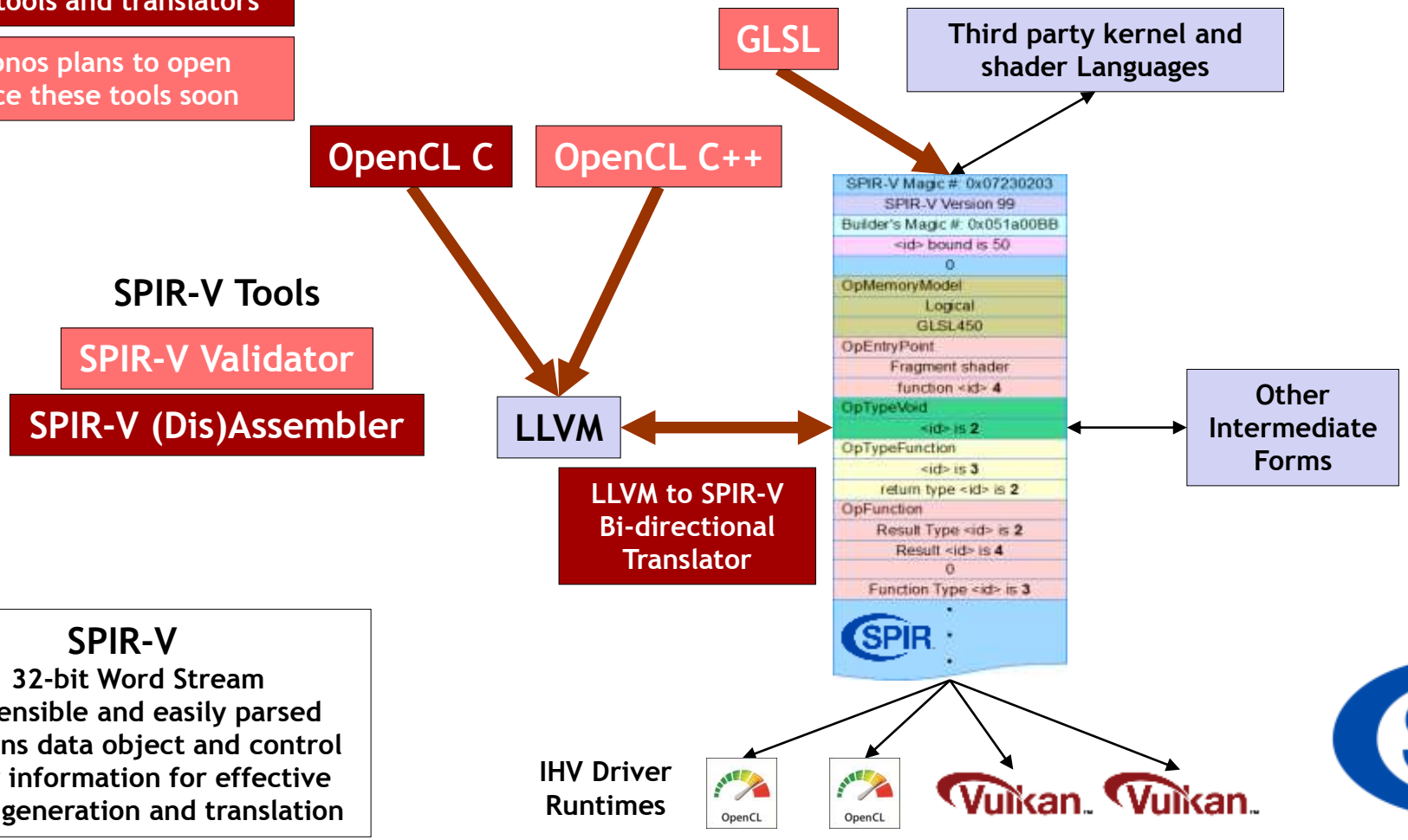
- **SPIR-V is first fully specified Khronos-defined SPIR standard**
  - Does not use LLVM to isolate from LLVM roadmap changes
  - Includes full flow control, graphics and parallel constructs beyond LLVM
  - Khronos has open sourced SPIR-V <-> LLVM conversion tools to enable construction of flexible toolchains that use both intermediate languages

SPIR	SPIR 1.2	SPIR 2.0	SPIR-V 1.0
LLVM Interaction	Uses LLVM 3.2	Uses LLVM 3.4	100% Khronos defined Round-trip lossless conversion
Compute Constructs	Metadata/Intrinsics	Metadata/Intrinsics	Native
Graphics Constructs	No	No	Native
Supported Language Feature Sets	OpenCL C 1.2	OpenCL C 1.2 OpenCL C 2.0	OpenCL C 1.2 / 2.0 OpenCL C++ and GLSL
OpenCL Ingestion	OpenCL 1.2 Extension	OpenCL 2.0 Extension	OpenCL 2.1 Core OpenCL 1.2 / 2.0 Extensions
Vulkan Ingestion	-	-	Vulkan 1.0 Core

Driving the SPIR-V Open Source Ecosystem

Khronos has open sourced these tools and translators

Khronos plans to open source these tools soon



SPIR-V

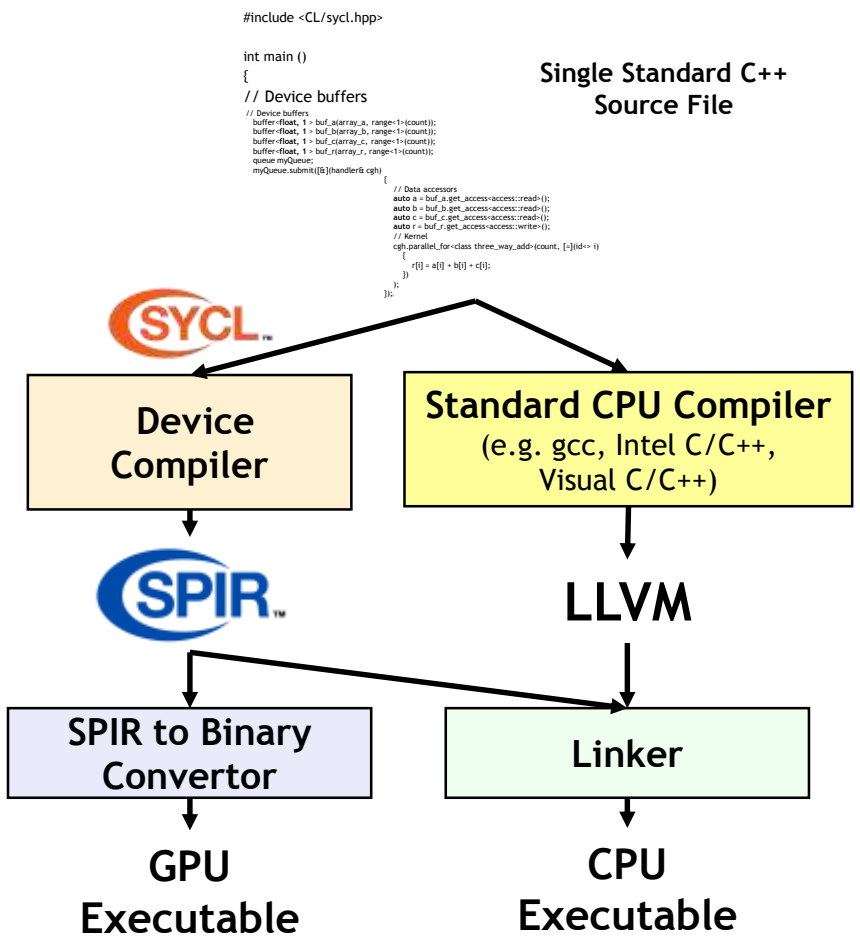
- 32-bit Word Stream
- Extensible and easily parsed
- Retains data object and control flow information for effective code generation and translation

SPIR-V Open Source Community Activity

- **Python byte code to SPIR-V Convertor**
  - Write shaders or kernels in Python, Encode and decode SPIR-V in Python
  - Dis(Assembler) with high level human readable assembler syntax
- **.NET IL to SPIR-V Convertor**
  - Write and debug shaders or kernels using C# , SPIR-V interpreter
- **Shade SPIR-V virtual machine**
  - Test and debug SPIR-V binaries for binary correctness in human readable format
- **Otherside SPIR-V virtual machine**
  - Academic software rasterizer project to produce C code from SPIR-V
- **Rust (Dis)Assembler**
  - Encode and decode SPIR-V binaries in Rust
- **Go (Dis)Assembler**
  - Encode and decode SPIR-V in Go, SPIR-V represented in Go data structures
- **Haskell EDSL**
  - SPIR-V like language embedded in Haskell with significantly relaxed layout constraints
- **Lisp SPIR-V Specification**
  - Lisp readable SPIR-V specification
- **JSON SPIR-V specification**
  - Conversion of HTML SPIR-V specification to JSON format
- **This is just the start….**

SYCL – Single Source Heterogeneous C++

- **Pronounced 'sickle'**
  - To go with 'spear' (SPIR)
- **C++11 code for multiple OpenCL devices**
  - Construct complex reusable algorithm templates using OpenCL for acceleration
- **C++ templates contain host & device code**
  - e.g. parallel_sort<MyType> (myData);
- **Cross-toolchain as well as cross-platform**
  - No language extensions – so standard C++ compilers can process SYCL source
- **Device compilers enable SYCL on devices**
  - Can have multiple device compilers linking into final executable



SYCL Status and Benefits

- **SYCL 1.2 Final spec released**
  - At IWOCL in May 2014
- **Multiple implementations**
  - Including open source triSYCL from AMD
  - https://github.com/amd/triSYCL
- **Developers can move quickly into writing SYCL code**
  - Provides methods for dealing with targets that do not have OpenCL(yet!)
- **A fallback CPU implementation is debuggable!**
  - Using normal C++ debuggers
  - Profiling tools also work on CPU device
- **Huge bonus for productivity and adoption**
  - Cost of entry to use SYCL very low

SYCL is a practical, open, royalty-free standard to deliver high performance software on today's highly-parallel systems

OpenCL Ecosystem

Implementers
Desktop/Mobile/Embedded/FPGA

Single Source C++ Programming

Core API and Language Specs

Portable Kernel Intermediate Language

Working Group Members
Apps/Tools/Tests/Courseware

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