Vulkan Shader Compiler Updates

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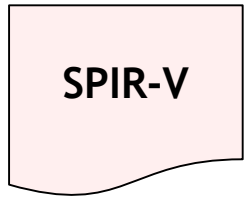
Overview

- Shader Toolchain
- Glslang: Updates
- SPIRV-Tools: Updates
- DXC: Goal & Status
- DXC: Feature Coverage
- Using DXC

Shader Toolchain: Projects



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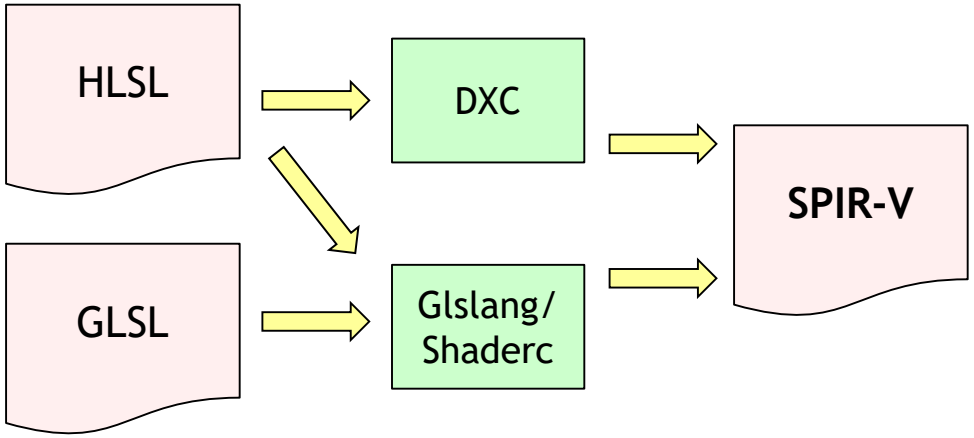
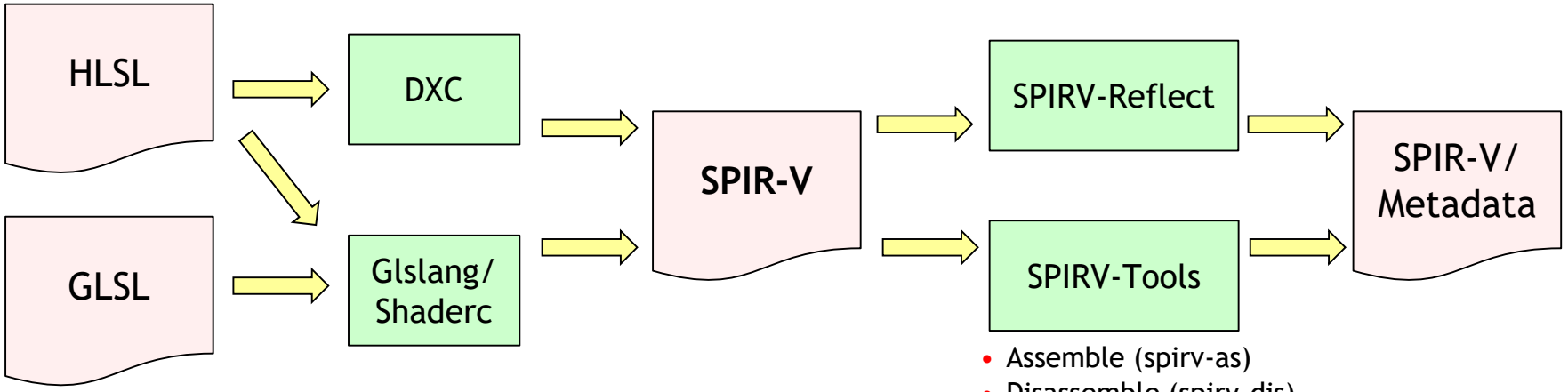
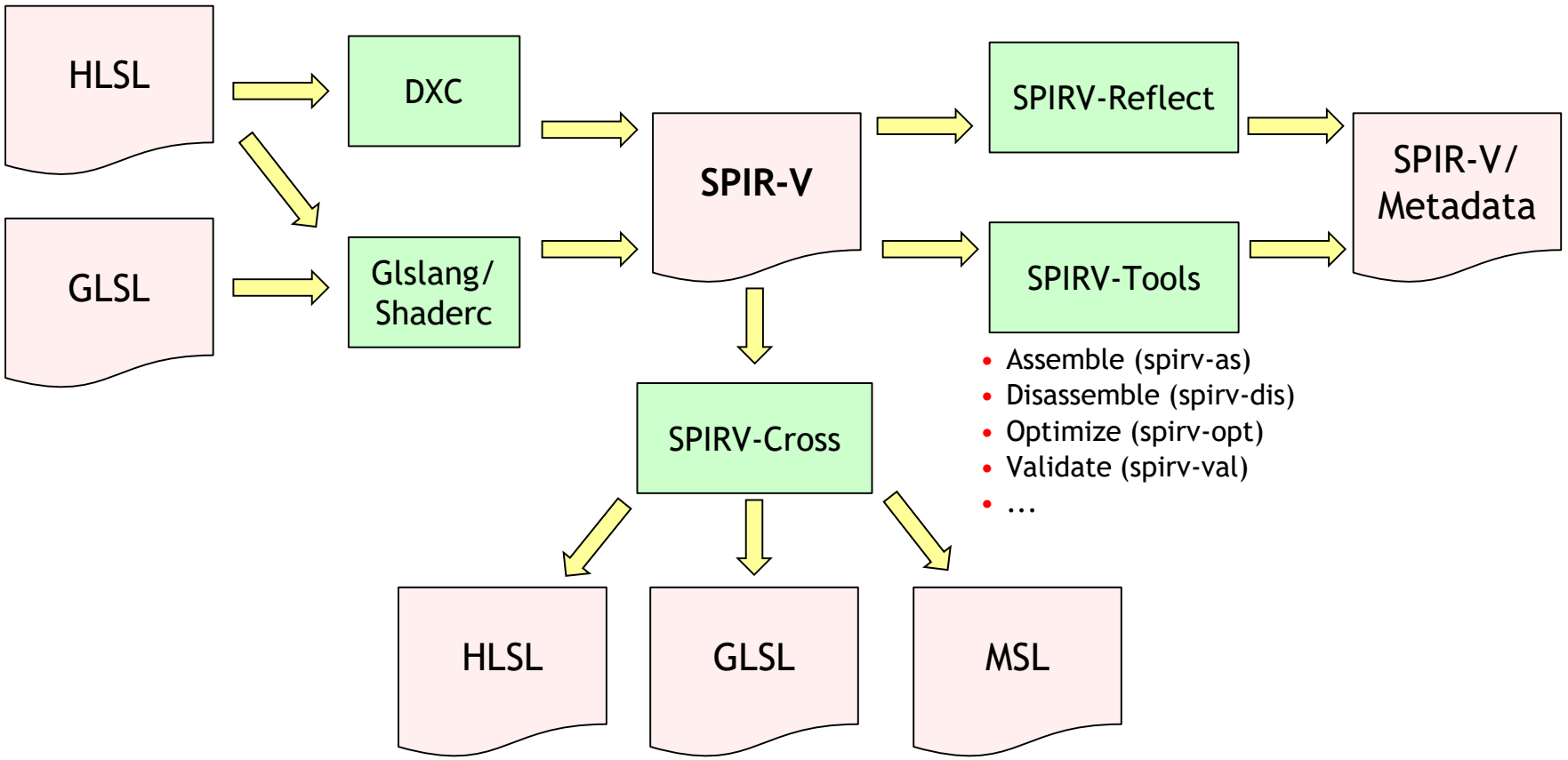


Shader Toolchain: Projects



- Assemble (spirv-as)
- Disassemble (spirv-dis)
- Optimize (spirv-opt)
- Validate (spirv-val)
- ...

Shader Toolchain: Projects



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Shader Toolchain: HLSL Compilation

- **Glslang**
  - Pioneered 6 months before Microsoft open sourced ...
- **DirectXShaderCompiler (DXC)**
  - Microsoft's next-gen HLSL compiler open sourced January 2017
  - Google contributing SPIR-V CodeGen (a.k.a. Spiregg) since April 2017
    - Learnt a lot from Glslang's experience
    - Cooperate with Glslang when features land in both
- **HLSL to SPIR-V compilation**
  - Recommend DXC as the forward path

Shader Toolchain: Two Compilers

	Glslang/Shaderc	DXC
High-level language	GLSL & HLSL	HLSL
Intermediate language	SPIR-V	SPIR-V & DXIL
Supported platform	Windows, Linux, macOS	Windows, Linux, macOS
Compiler library size	Small	Big (LLVM/Clang)
HLSL shader model	Up to 5.1, + 6.0 wave ops	Up to 6.2
HLSL validation	No	Yes

Glslang: Updates

- **Supported lots of new extensions**
  - SPV_EXT_descriptor_indexing (for GLSL)
  - SPV_KHR_8bit_storage (for GLSL)
  - GL_EXT_shader_16bit_storage
  - SPV_GOOGLE_hlsl_functionality1 (for HLSL)
  - ...
- **Supported linking GLSL compilation units**
  - For a single stage
- **Better integration with other tools**
  - Adopted standard disassembly (spirv-dis)
  - Updated optimization (spirv-opt)
  - More information for debugging
- **Incremental improvements & fixes**
- **Changed to semantic versioning**

SPIRV-Tools: Updates

- **Legalization works**
  - Literal HLSL translation may generate illegal SPIR-V for Vulkan
  - Legalization: transformations to legalize SPIR-V
  - Sharing infrastructure with optimizations
- **Stable optimization (spirv-opt)**
  - Added loop optimizations
  - Supported many instruction combining cases
  - Better dead code elimination
  - Whole-array copy propagation
  - Greatly improved run time
  - ...
- **Better validation (spirv-val)**
  - Builtin variable
  - Resource layout
  - Better error message
  - ...

DXC: Goal

Make HLSL for Vulkan Shader Authoring Great

DXC: Current Status

- Stable now!

- Covered ~all native HLSL features
- Covered ~all Vulkan KHR/EXT extensions

- Better optimization support
- Better debugging support

- Supported non-Windows platforms
  - Linux, macOS

Coverage: HLSL Shader Models

- **Shader Model 5.1 and below** ✓
  - Excluding features without Vulkan equivalent
- **Shader Model 6.0** ✓
  - Wave intrinsics, 64-bit integers
- **Shader Model 6.1** ✓
  - SV_ViewID, SV_Barycentrics
- **Shader Model 6.2 (WIP)** •
  - 16-bit types ✓
  - Denorm mode •

Coverage: HLSL Language Features

- **C-ish features** ✔
  - Math types
  - Various operations
  - Control flows
  - Functions
- **C++-ish features** ✔
  - Resource types and methods
  - Namespaces
  - OO (static) class members
  - OO (static) class methods
  - OO this pointer
  - OO inheritance
- **Common code patterns** ✔
  - Grouping resources in structs
  - Aliasing structured buffers

Coverage: Vulkan/SPIR-V

- **Supported Vulkan 1.0 & 1.1** ✔
  - Push constant, subpass input, …
  - Subgroup operations, …
- **Supported Extensions** ✔
  - SPV_KHR_16bit_storage
  - SPV_KHR_device_group
  - SPV_KHR_multivew
  - SPV_KHR_post_depth_coverage
  - SPV_KHR_shader_draw_parameters
  - SPV_EXT_descriptor_indexing
  - SPV_EXT_fragment_fully_covered
  - SPV_EXT_shader_stencil_support
  - SPV_AMD_shader_explicit_vertex_parameter
  - SPV_GOOGLE_hlsl_functionality1

Using DXC: Downloads and Docs

- **Pre-built binaries**
  - Rolling release build from latest master branch:
  - http://khr.io/dxcappveyorbuild
- **User manual**
  - How HLSL and Vulkan language features are translated:
  - http://khr.io/hlsl2spirv
- **Compiler internals**
  - Detailed blog posts on translation difficulties and design choices of selected topics:
  - antiagainst.github.io/categories/hlsl-for-vulkan/ (WIP)

Using DXC: Linux & macOS Support

- **Windows specific techniques**
  - COM, SAL, etc.
  - Introduced to solve technical issues on the Windows platform
  - No longer compilable/runnable on non-Windows platforms
- **Implemented adapters for other platforms**
- **Master branch fully supported Linux and macOS now!**
  - Travis CI running for all commits and pull requests

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Using DXC: Resource Descriptor Assignment

- **If able to change source code:**
  - `[[vk::binding(<binding#>, <set#>)]]`
  - `[[vk::counter_binding(<binding#>)]]` (for associated counter)

- **If unable to change source code:**
  - Using `:register(xX, spaceY)`
    - `x`: ignored, `X`: binding#, `Y`: set#
  - With command-line shift
    - -fvk-b-shift <shift-amount> <set#>
    - -fvk-t-shift <shift-amount> <set#>
    - -fvk-s-shift= <shift-amount> <set#>
    - -fvk-u-shift= <shift-amount> <set#>
    - Shift for all sets: <set#> ← “all”
  - Or specifying 1:1 mapping
    - -fvk-bind-register xX Y <binding#> <set#>

Using DXC: Resource Memory Layout

- **Supported three sets of layout rules**
  - Vulkan, DirectX, OpenGL

Rules	CL Option	Uniform Buffer	Storage Buffer
Vulkan	(default)	“vector-relaxed” std140	“vector-relaxed” std430
DirectX	-fvk-use-dx-layout	fxc behavior	fxc behavior
OpenGL	-fvk-use-gl-layout	std140	std430

- **Supported `:packoffset()`**
  - Native HLSL feature, only for cbuffer
- **Supported `[[vk::offset(X)]]`**
  - Vulkan specific, for all structs

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Using DXC: Optimization

- **-O: running spirv-opt standard performance recipe**
  - Running by default
  - All optimization levels are the same right now

- **-Oconfig=: specifying your own passes**
  - Same as spirv-opt -Oconfig=
  - E.g., -Oconfig=-O,--loop-unroll,-O

Using DXC: Debugging and Reflection

- **-Zi: emitting debug information**
  - Full path for main source file
  - Preprocessed entry point
  - Line information for certain instructions

- **-fspv-reflect: emitting reflection information**
  - Using the SPV_GOOGLE_hlsl_functionality1 extension
  - Original HLSL semantic for input/output variables
  - Relation between main buffer and associated counter

DXC: What's Coming

- More Vulkan extensions
- More debugging information

Credits

- **Individuals (apologies if missing anyone)**
  - DXC: Greg Roth, Hai Nguyen (Google)
  - spirv-opt: Diego Novillo (Google), Steven Perron (Google)
    Alan Baker (Google), Greg Fischer (LunarG)
  - Guidance: David Neto (Google), John Kessenich (Google)
- **Companies**
  - Microsoft
  - AMD, Intel, LunarG, Nvidia, Valve
- **The community**

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Hiring

Thank you!

:)

We're Hiring!

Contact Kevin Lusby (kevinlusby@google.com)!

Come visit us at the Google booth!