Specialization Constants

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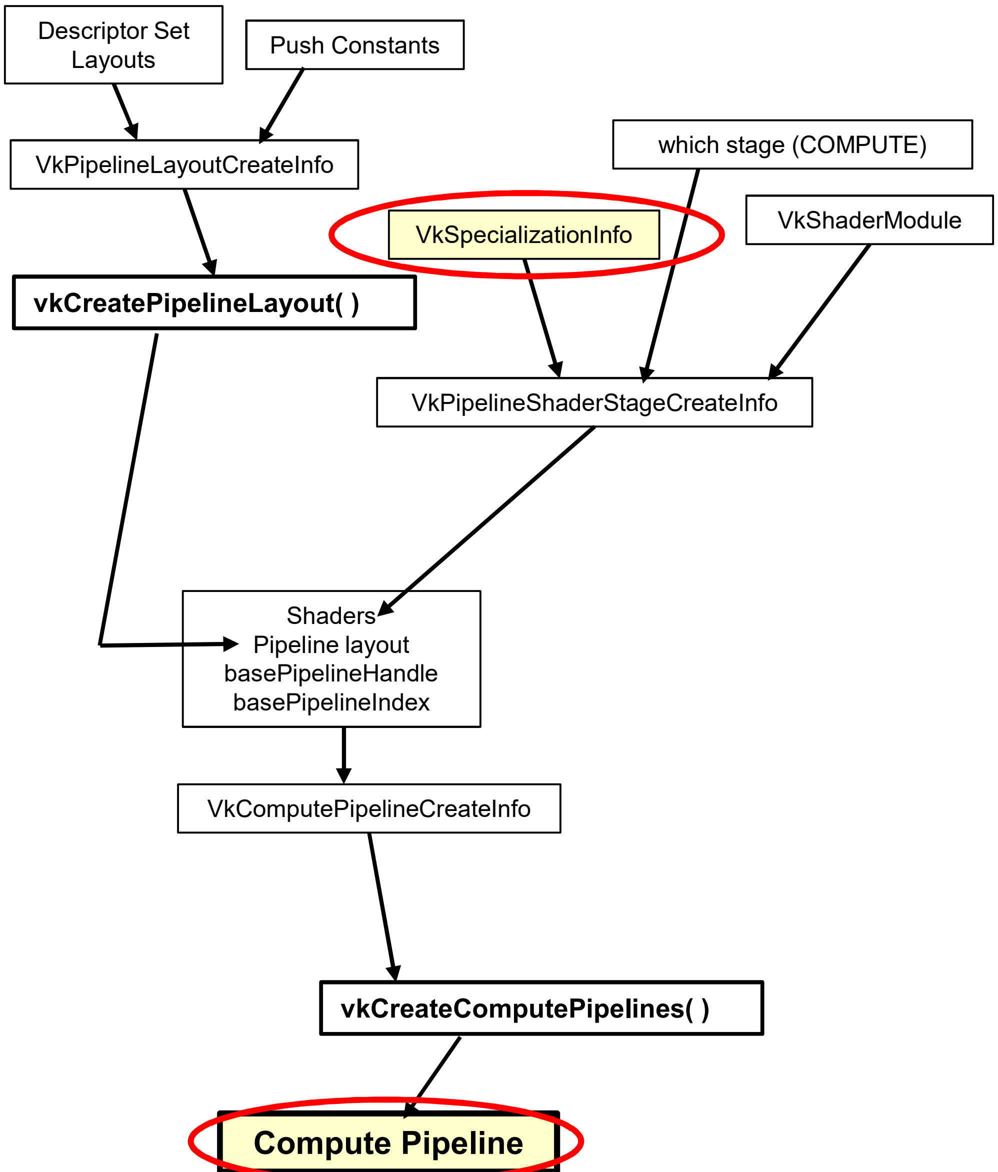
Remember the Compute Pipeline?



What Are Specialization Constants?

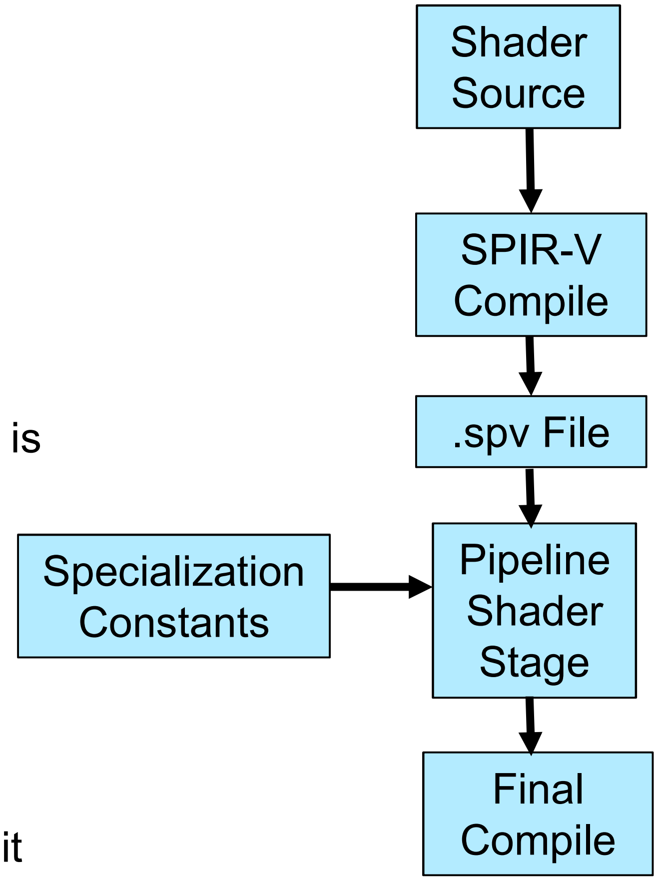
In Vulkan, all shaders get halfway-compiled into SPIR-V and then the rest-of-the-way compiled by the Vulkan driver.

Normally, the half-way compile finalizes all constant values and compiles the code that uses them.

But, it would be nice every so often to have your Vulkan program sneak into the halfway-compiled binary and manipulate some constants at runtime. This is what Specialization Constants are for. A Specialization Constant is a way of injecting an integer, Boolean, uint, float, or double constant into a *halfway-compiled* version of a shader right before the *rest-of-the-way* compilation.

That final compilation happens when you call **vkCreateComputePipelines( )**

Without Specialization Constants, you would have to commit to a final value before the SPIR-V compile was done, which could have been a long time ago

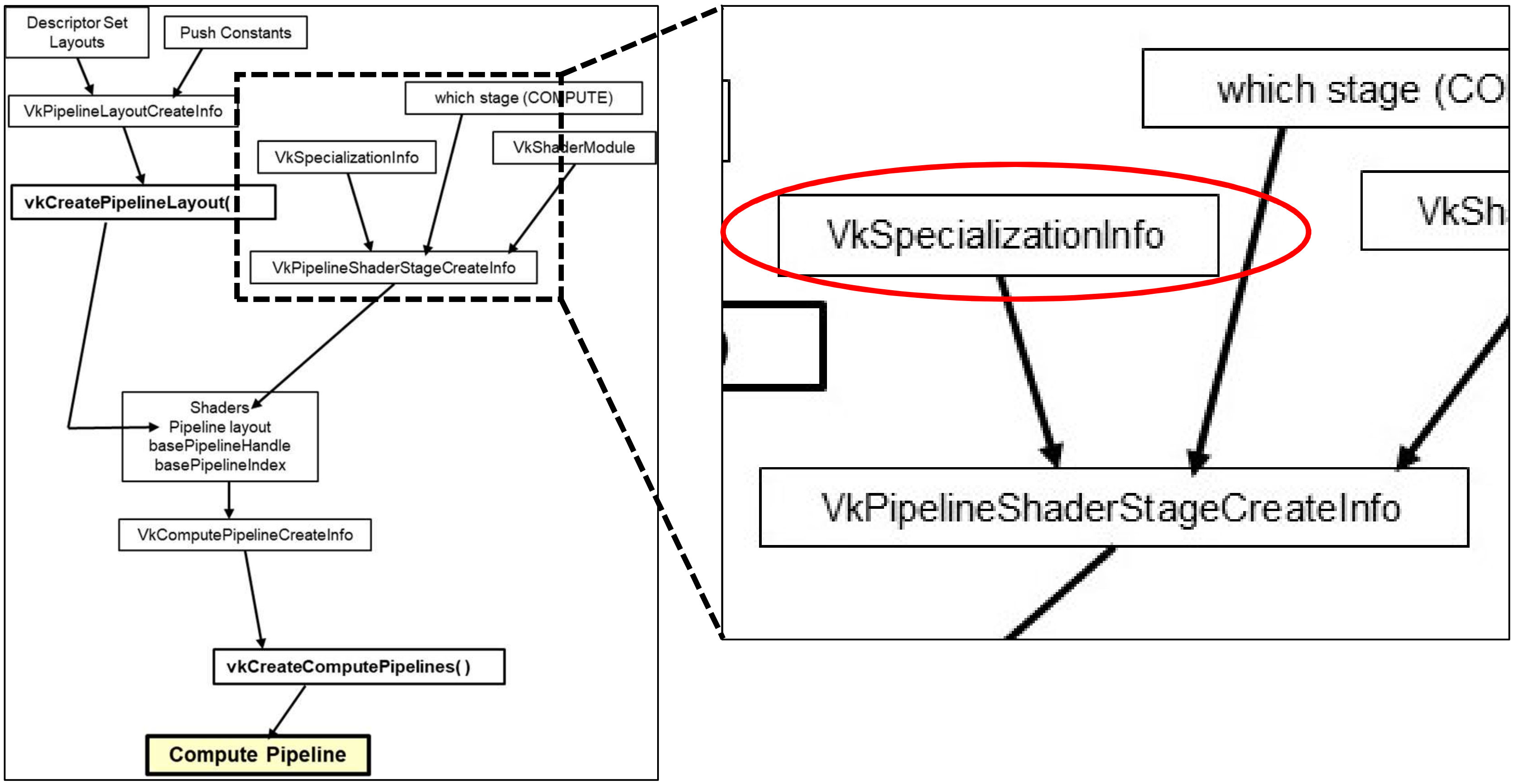


Why Do We Need Specialization Constants?

Specialization Constants could be used for:

- Setting the work-items per work-group in a compute shader
- Setting a Boolean flag and then eliminating the if-test that used it
- Setting an integer constant and then eliminating the switch-statement that looked for it
- Making a decision to unroll a for-loop because the number of passes through it are small enough
- Collapsing arithmetic expressions into a single value
- Collapsing trivial simplifications, such as adding zero or multiplying by 1

Specialization Constants are Described in the Compute Pipeline



Specialization Constant Example -- Setting an Array Size

In the compute shader

```
layout( constant_id = 7 )  const int ASIZE = 32;

int array[ASIZE];
```

In the Vulkan C/C++ program:

```
int asize = 64;

VkSpecializationMapEntry     vsme[1];        // one array element for each
                                             //     Specialization Constant
    vsme[0].constantID = 7;
    vsme[0].offset = 0;                // # bytes into the Specialization Constant
                                       //     array this one item is
    vsme[0].size = sizeof(asize);      // size of just this Specialization Constant

VkSpecializationInfo       vsi;
    vsi.mapEntryCount = 1;
    vsi.pMapEntries = &vsme[0];
    vsi.dataSize = sizeof(asize);          // size of all the Specialization Constants together
    vsi.pData = &asize;                    // array of all the Specialization Constants
```

Linking the Specialization Constants into the Compute Pipeline

```
int asize = 64;

VkSpecializationMapEntry  vsme[1];
        vsme[0].constantID = 7;
        vsme[0].offset = 0;
        vsme[0].size = sizeof(asize);

VkSpecializationInfo          vsi;
        vsi.mapEntryCount = 1;
        vsi.pMapEntries = &vsme[0];
        vsi.dataSize = sizeof(asize);
        vsi.pData = &asize;

VkPipelineShaderStageCreateInfo              vpssci;
            vpssci.sType = VK_STRUCTURE_TYPE_PIPELINE_SHADER_STAGE_CREATE_INFO;
            vpssci.pNext = nullptr;
            vpssci.flags = 0;
            vpssci.stage = VK_SHADER_STAGE_COMPUTE_BIT;
            vpssci.module = computeShader;
            vpssci.pName = "main";
            vpssci.pSpecializationInfo = &vsi;

VkComputePipelineCreateInfo                  vcpci[1];
            vcpci[0].sType = VK_STRUCTURE_TYPE_COMPUTE_PIPELINE_CREATE_INFO;
            vcpci[0].pNext = nullptr;
            vcpci[0].flags = 0;
            vcpci[0].stage = vpssci;
            vcpci[0].layout = ComputePipelineLayout;
            vcpci[0].basePipelineHandle = VK_NULL_HANDLE;
            vcpci[0].basePipelineIndex = 0;

result = vkCreateComputePipelines( LogicalDevice, VK_NULL_HANDLE, 1, &vcpci[0], PALLOCATOR, OUT &ComputePipeline );
```

Specialization Constant Example – Setting Multiple Constants

In the compute shader

```
layout( constant_id =   9 )  const int     a = 1;
layout( constant_id = 10 )  const int     b = 2;
layout( constant_id =  11 )  const float   c = 3.14;
```

In the C/C++ program:

```
struct abc { int a, int b, float c; } abc;

VkSpecializationMapEntry     vsme[3];
        vsme[0].constantID = 9;
        vsme[0].offset = offsetof( abc, a );
        vsme[0].size = sizeof(abc.a);
        vsme[1].constantID = 10;
        vsme[1].offset = offsetof( abc, b );
        vsme[1].size = sizeof(abc.b);
        vsme[2].constantID = 11;
        vsme[2].offset = offsetof( abc, c );
        vsme[2].size = sizeof(abc.c);

VkSpecializationInfo            vsi;
        vsi.mapEntryCount = 3;
        vsi.pMapEntries = &vsme[0];
        vsi.dataSize = sizeof(abc);                 // size of all the Specialization Constants together
        vsi.pData = &abc;                           // array of all the Specialization Constants
```

It's important to use sizeof( ) and offsetof( ) instead of hardcoding numbers!

Specialization Constants – Setting the Number of Work-items Per Work-Group in the Compute Shader

In the compute shader

```
layout( local_size_x_id=12 )  in;

layout( local_size_x = 32,  local_size_y = 1, local_size_z = 1 )   in;
```

In the C/C++ program:

```
int numXworkItems = 64;

VkSpecializationMapEntry       vsme[1];
        vsme[0].constantID = 12;
        vsme[0].offset = 0;
        vsme[0].size = sizeof(int);

VkSpecializationInfo        vsi;
        vsi.mapEntryCount = 1;
        vsi.pMapEntries = &vsme[0];
        vsi.dataSize = sizeof(int);
        vsi.pData = &numXworkItems;
```