Vulkan

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Who is the Real Vulkan?

Can you notice the difference? It's subtle!

Who is the Khronos Group?

The Khronos Group, Inc. is a non-profit member-funded industry consortium, focused on the creation of open standard, royalty-free application programming interfaces (APIs) for authoring and accelerated playback of dynamic media on a wide variety of platforms and devices. Khronos members may contribute to the development of Khronos API specifications, vote at various stages before public deployment, and accelerate delivery of their platforms and applications through early access to specification drafts and conformance tests.

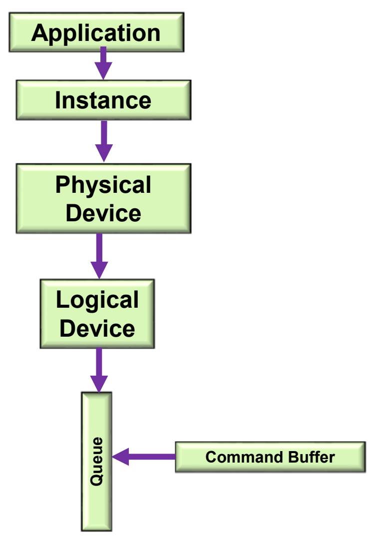
COLLADA, DataFormat, EGL, glTF, NNEF, OpenCL, OpenGL ES, OpenGL, OpenGL SC, OpenVG, OpenXR, OpenVX, SPIR, SYCL, Vulkan, WebGL

Playing "Where's Waldo" with OSU's Khronos Membership

Vulkan

- Largely derived from AMD's *Mantle* API
- Also heavily influenced by Apple's *Metal* API and Microsoft's *DirectX 12*
- Goal: much less driver complexity and overhead than OpenGL has
- Goal: much less user hand-holding
- Goal: higher single-threaded performance than OpenGL can deliver
- Goal: able to do multithreaded graphics
- Goal: able to handle tiled rendering

Vulkan: a Simplified Block Diagram

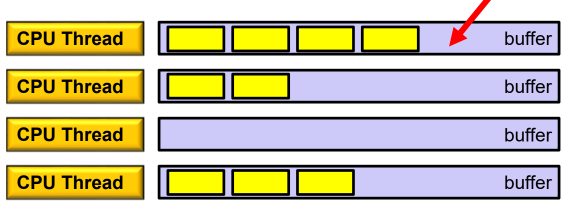


Vulkan Code has a Distinct "Style"


```
VkBufferCreateInfo                vbci;
        vbci.sType = VK_STRUCTURE_TYPE_BUFFER_CREATE_INFO;
        vbci.pNext = nullptr;
        vbci.flags = 0;
        vbci.size = << buffer size in bytes >>
        vbci.usage = VK_USAGE_UNIFORM_BUFFER_BIT;
        vbci.sharingMode = VK_SHARING_MODE_EXCLUSIVE;
        vbci.queueFamilyIndexCount = 0;
        vbci.pQueueFamilyIndices = nullptr;

VK_RESULT result = vkCreateBuffer ( LogicalDevice, IN &vbci, PALLOCATOR,  OUT &Buffer );

VkMemoryRequirements          vmr;

result = vkGetBufferMemoryRequirements( LogicalDevice, Buffer, OUT &vmr );      // fills vmr

VkMemoryAllocateInfo             vmai;
        vmai.sType = VK_STRUCTURE_TYPE_MEMORY_ALLOCATE_INFO;
        vmai.pNext = nullptr;
        vmai.flags = 0;
        vmai.allocationSize = vmr.size;
        vmai.memoryTypeIndex = 0;

result = vkAllocateMemory( LogicalDevice, IN &vmai, PALLOCATOR, &MatrixBufferMemoryHandle );

result = vkBindBufferMemory( LogicalDevice, Buffer, MatrixBufferMemoryHandle, 0 );
```


Vulkan Command Buffers

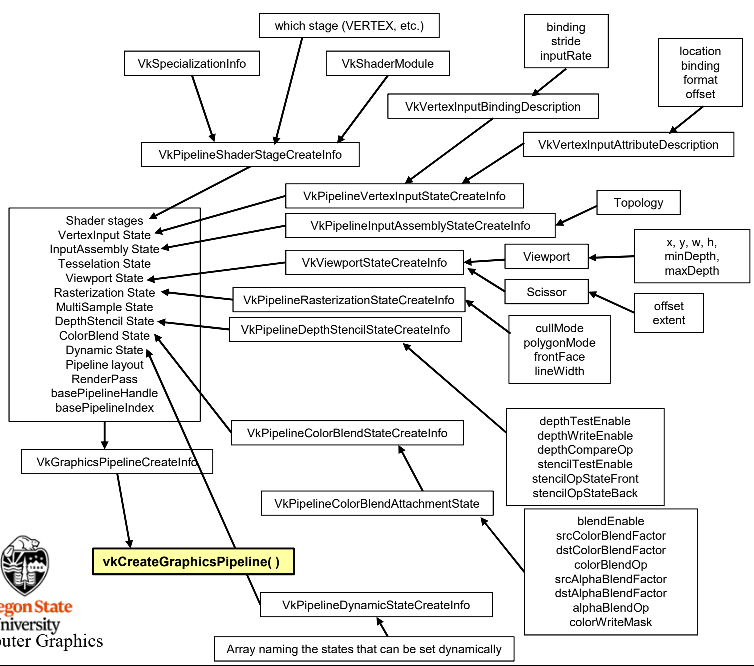
- Graphics commands are sent to command buffers
- Think OpenCL…
- E.g., *vkCmdDoSomething(cmdBuffer, …);*
- You can have as many simultaneous Command Buffers as you want
- Buffers are flushed when they are full or when the application wants them flushed
- Each command buffer can be filled from a different thread (i.e., filling is thread-safe)



Vulkan Graphics Pipelines

- In OpenGL, your graphics “pipeline state” is whatever combination you most recently set: color, transformations, textures, shaders, etc.
- Changing the state is very expensive
- Vulkan forces you to set all your state at once into a “pipeline state object” (PSO) and then invoke the entire PSO whenever you want to use that state combination
- Think of pipeline state as being immutable.
- Potentially, you could have thousands of these pre-prepared states – if there are N things to set, there would be N! possible combinations.
- This is a good time to talk about how game companies view Vulkan…

Vulkan: Creating a Pipeline



Vulkan GPU Memory

- Your application allocates GPU memory for the objects it needs
- You map memory to the CPU address space for access
- Your application is responsible for making sure what you put into that memory is actually in the right format, is the right size, etc.

From the Shader Storage Buffer notes:

```
glGenBuffers( 1, &posSSbo);
glBindBuffer( GL_SHADER_STORAGE_BUFFER, posSSbo );
glBufferData( GL_SHADER_STORAGE_BUFFER, NUM_PARTICLES * sizeof(struct pos), NULL, GL_STATIC_DRAW );

GLint bufMask = GL_MAP_WRITE_BIT | GL_MAP_INVALIDATE_BUFFER_BIT ;          // the invalidate makes a big difference when re-writing

struct pos *points = (struct pos *) glMapBufferRange( GL_SHADER_STORAGE_BUFFER, 0, NUM_PARTICLES * sizeof(struct pos), bufMask );
```


Vulkan Render Passes

- Drawing is done inside a render pass
- Each render pass contains what framebuffer attachments to use
- Each render pass is told what to do when it begins and ends

Vulkan Synchronization

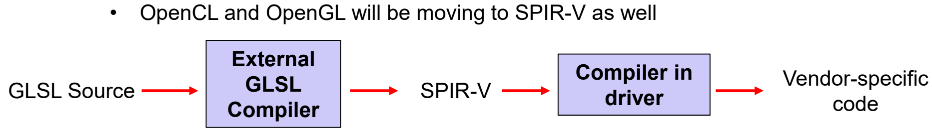
13

- Synchronization is the responsibility of the *application*
- Events can be set, polled, and waited for (much like OpenCL)
- Vulkan does not ever lock – that's the application's job
- Threads can concurrently read from the same object
- Threads can concurrently write to different objects

Vulkan Shaders

14

- GLSL is the same as before … almost
- For places it's not, an implied
  #define VULKAN 100
  is automatically supplied by the compiler
- You pre-compile your shaders with an external compiler
- Your shaders get turned into an intermediate form known as SPIR-V
- SPIR-V gets turned into fully-compiled code at runtime
- The SPIR-V spec has been public for months –new shader languages are surely being developed
- OpenCL and OpenGL will be moving to SPIR-V as well



Advantages:

1. Software vendors don't need to ship their shader source
2. Software can launch faster because half of the compilation has already taken place
3. This guarantees a common front-end syntax
4. This allows for other language front-ends

So What Do We All Do Now?

- I don't see Vulkan completely replacing OpenGL *ever*
- However, I wonder if Khronos will become less and less excited about adding new extensions to OpenGL
- And, I also wonder if vendors will become less and less excited about improving OpenGL drivers
- I see the OSU Vulkan class as always being a one-term standalone course, not part of another OpenGL-based course.

So What Do We All Do Now?

This is what I think the model of the immediate future is: