Vulkan Topologies

typedef enum VkPrimitiveTopology
{
    VK_PRIMITIVE_TOPOLOGY_POINT_LIST = 0,
    VK_PRIMITIVE_TOPOLOGY_LINE_LIST = 1,
    VK_PRIMITIVE_TOPOLOGY_LINE_STRIP = 2,
    VK_PRIMITIVE_TOPOLOGY_TRIANGLE_LIST = 3,
    VK_PRIMITIVE_TOPOLOGY_TRIANGLE_STRIP = 4,
    VK_PRIMITIVE_TOPOLOGY_TRIANGLE_FAN = 5,
    VK_PRIMITIVE_TOPOLOGY_LINE_LIST_WITH_ADJACENCY = 6,
    VK_PRIMITIVE_TOPOLOGY_LINE_STRIP_WITH_ADJACENCY = 7,
    VK_PRIMITIVE_TOPOLOGY_TRIANGLE_LIST_WITH_ADJACENCY = 8,
    VK_PRIMITIVE_TOPOLOGY_TRIANGLE_STRIP_WITH_ADJACENCY = 9,
    VK_PRIMITIVE_TOPOLOGY_PATCH_LIST = 10,
} VkPrimitiveTopology;
Vulkan Topologies

VK_PRIMITIVE_TOPOLOGY_POINT_LIST

VK_PRIMITIVE_TOPOLOGY_LINE_LIST

VK_PRIMITIVE_TOPOLOGY_LINE_STRIP

VK_PRIMITIVE_TOPOLOGY_TRIANGLE_LIST

VK_PRIMITIVE_TOPOLOGY_TRIANGLE_STRIP

VK_PRIMITIVE_TOPOLOGY_TRIANGLE_FAN

A Colored Cube Example

static GLuint CubeTriangleIndices[3][3] = {
  { 0, 2, 3 },
  { 0, 3, 1 },
  { 4, 5, 7 },
  { 4, 7, 6 },
  { 1, 3, 7 },
  { 1, 7, 5 },
  { 0, 4, 6 },
  { 0, 6, 2 },
  { 2, 6, 7 },
  { 2, 7, 3 },
  { 0, 1, 5 },
  { 0, 5, 4 }
};

static GLshort CubeTriangleIndices[3][3] = {
  { 0, 2, 3 },
  { 0, 3, 1 },
  { 4, 5, 7 },
  { 4, 7, 6 },
  { 1, 3, 7 },
  { 1, 7, 5 },
  { 0, 4, 6 },
  { 0, 6, 2 },
  { 2, 6, 7 },
  { 2, 7, 3 },
  { 0, 1, 5 },
  { 0, 5, 4 }
};
Triangles in an Array of Structures

From the file SampleVertexData.cpp:

```cpp
struct vertex
{
    glm::vec3  position;
    glm::vec3  normal;
    glm::vec3  color;
    glm::vec2  texCoord;
};

struct vertex VertexData[ ] = {
    // triangle 0-2-3:
    // vertex #0:
    { -1.0, -1.0, -1.0 },
    { 0.0,  0.0, -1.0 },
    { 0.0,  0.0,  0.0 },
    { 1.0,  1.0 }},
    // vertex #2:
    { -1.0,  1.0, -1.0 },
    { 0.0,  0.0, -1.0 },
    { 0.0,  1.0,  0.0 },
    { 1.0,  1.0 }},
    // vertex #3:
    {  1.0,  1.0, -1.0 },
    { 0.0,  0.0, -1.0 },
    { 1.0,  1.0,  0.0 },
    { 0.0,  1.0 }
};
```

MyBuffer MyVertexDataBuffer;

Init05MyVertexDataBuffer( sizeof(VertexData), &MyVertexDataBuffer );
Fill05DataBuffer( MyVertexDataBuffer, (void *) VertexData );

Filling the Vertex Buffer

```cpp
MyBuffer MyVertexDataBuffer;

Init05MyVertexDataBuffer( sizeof(VertexData), &MyVertexDataBuffer );
Fill05DataBuffer( MyVertexDataBuffer, (void *) VertexData );

VkResult
Init05MyVertexDataBuffer( IN VkDeviceSize size, OUT MyBuffer * pMyBuffer )
{
    VkResult result = Init05DataBuffer( size, VK_BUFFER_USAGE_VERTEX_BUFFER_BIT, pMyBuffer );
    return result;
}
```
A Reminder of What Init05DataBuffer Does

```c
VkResult Init05DataBuffer( VkDeviceSize size, VkBufferUsageFlags usage, OUT MyBuffer *pMyBuffer )
{
    VkResult result = VK_SUCCESS;
    VkBufferCreateInfo vbci;
    vbci.sType = VK_STRUCTURE_TYPE_BUFFER_CREATE_INFO;
    vbci.pNext = nullptr;
    vbci.flags = 0;
    vbci.size = size;
    vbci.usage = usage;
    vbci.sharingMode = VK_SHARING_MODE_EXCLUSIVE;
    vbci.queueFamilyIndexCount = 0;
    vbci.pQueueFamilyIndices = (const uint32_t *)nullptr;
    result = vkCreateBuffer( LogicalDevice, IN &vbci, PALLOCATOR, OUT &pMyBuffer->buffer );

    VkMemoryRequirements vmr;
    vkGetBufferMemoryRequirements( LogicalDevice, IN pMyBuffer->buffer, OUT &vmr );         // fills vmr
    VkMemoryAllocateInfo vmai;
    vmai.sType = VK_STRUCTURE_TYPE_MEMORY_ALLOCATE_INFO;
    vmai.pNext = nullptr;
    vmai.allocationSize = vmr.size;
    vmai.memoryTypeIndex = FindMemoryThatIsHostVisible( );
    VkDeviceMemory vdm;
    result = vkAllocateMemory( LogicalDevice, IN &vmai, PALLOCATOR, OUT &vdm );
    pMyBuffer->vdm = vdm;
    result = vkBindBufferMemory( LogicalDevice, pMyBuffer->buffer, IN vdm, 0 );             // 0 is the offset
    return result;
}
```

Telling the Pipeline about its Input

We will come to the Pipeline later, but for now, know that a Vulkan pipeline is essentially a very large
data structure that holds (what OpenGL would call) the state, including how to parse its input.

```c
struct vertex
{
    glm::vec3 position;
    glm::vec3 normal;
    glm::vec3 color;
    glm::vec2 texCoord;
};
```

```c
VkVertexInputBindingDescription vvibd[1]; // one of these per buffer data buffer
vvibd[0].binding = 0; // which binding # this is
vvibd[0].stride = sizeof( struct vertex ); // bytes between successive structs
vvibd[0].inputRate = VK_VERTEX_INPUT_RATE_VERTEX;
```
Telling the Pipeline about its Input

We will come to the Pipeline later, but for now, know that a Vulkan Pipeline is essentially a very large data structure that holds (what OpenGL would call) the state, including how to parse its input.

```cpp
struct vertex
{
    glm::vec3 position;
    glm::vec3 normal;
    glm::vec3 color;
    glm::vec2 texCoord;
};

layout( location = 0 ) in vec3 aVertex;
layout( location = 1 ) in vec3 aNormal;
layout( location = 2 ) in vec3 aColor;
layout( location = 3 ) in vec2 aTexCoord;
```

```cpp
VkVertexInputAttributeDescription vviad[4]; // array per vertex input attribute
    // 4 = vertex, normal, color, texture coord
    vviad[0].location = 0;                  // location in the layout decoration
    vviad[0].binding = 0;                   // which binding description this is part of
    vviad[0].format = VK_FORMAT_VEC3;       // x, y, z
    vviad[0].offset = offsetof( struct vertex, position );                  // 0

    vviad[1].location = 1;
    vviad[1].binding = 0;
    vviad[1].format = VK_FORMAT_VEC3;       // nx, ny, nz
    vviad[1].offset = offsetof( struct vertex, normal );                    // 12

    vviad[2].location = 2;
    vviad[2].binding = 0;
    vviad[2].format = VK_FORMAT_VEC3;       // r, g, b
    vviad[2].offset = offsetof( struct vertex, color );                    // 24

    vviad[3].location = 3;
    vviad[3].binding = 0;
    vviad[3].format = VK_FORMAT_VEC2;       // s, t
    vviad[3].offset = offsetof( struct vertex, texCoord );                // 36
```

```cpp
VkPipelineVertexInputStateCreateInfo vpvisci;          // used to describe the input vertex attributes
    vpvisci.sType = VK_STRUCTURE_TYPE_PIPELINE_VERTEX_INPUT_STATE_CREATE_INFO;
    vpvisci.pNext = nullptr;
    vpvisci.flags = 0;
    vpvisci.vertexBindingDescriptionCount = 1;
    vpvisci.pVertexBindingDescriptions = vvibd;
    vpvisci.vertexAttributeDescriptionCount = 4;
    vpvisci.pVertexAttributeDescriptions = vviad;
```

```cpp
VkPipelineInputAssemblyStateCreateInfo vpiasci;        // used to choose which assembling to do
    vpiasci.sType = VK_STRUCTURE_TYPE_PIPELINE_INPUT_ASSEMBLY_STATE_CREATE_INFO;
    vpiasci.pNext = nullptr;
    vpiasci.flags = 0;
    vpiasci.topology = VK_PRIMITIVE_TOPOLOGY_TRIANGLE_LIST;
```
Telling the Pipeline about its Input

We will come to the Pipeline later, but for now, know that a Vulkan Pipeline is essentially a very large data structure that holds (what OpenGL would call) the state, including how to parse its input.

```c
VkGraphicsPipelineCreateInfo vgpci;
vgpci.sType = VK_STRUCTURE_TYPE_GRAPHICS_PIPELINE_CREATE_INFO;
vgpci.pNext = nullptr;
vgpci.flags = 0;
vgpci.stageCount = 2;                // number of shader stages in this pipeline
vgpci.pStages = vpssci;
vgpci.pVertexInputState = &vpvisci;
vgpci.pInputAssemblyState = &vpiasci;
vgpci.pTessellationState = (VkPipelineTessellationStateCreateInfo *)&vptsci;  // &vptsci
vgpci.pViewportState = &vpvsci;
vgpci.pRasterizationState = &vprsci;
vgpci.pMultisampleState = &vpmsci;
vgpci.pDepthStencilState = &vpdssci;
vgpci.pColorBlendState = &vpcbsci;
vgpci.layout = IN GraphicsPipelineLayout;
vgpci.renderPass = IN RenderPass;
vgpci.subpass = 0;                              // subpass number
vgpci.basePipelineHandle = (VkPipeline) VK_NULL_HANDLE;
vgpci.basePipelineIndex = 0;
result = vkCreateGraphicsPipelines( LogicalDevice, VK_NULL_HANDLE, 1, IN &vgpci,
PALLOCATOR, OUT pGraphicsPipeline );
```

Telling the Command Buffer what Vertices to Draw

We will come to Command Buffers later, but for now, know that you will specify the vertex buffer that you want drawn.

```c
VkBuffer buffers[1] = MyVertexDataBuffer.buffer;
vkCmdBindVertexBuffers( CommandBuffers[nextImageIndex], 0, 1, vertexDataBuffers, offsets );
const uint32_t vertexCount = sizeof( VertexData ) / sizeof( VertexData[0] );
const uint32_t instanceCount = 1;
const uint32_t firstVertex = 0;
const uint32_t firstInstance = 0;
vkCmdDraw( CommandBuffers[nextImageIndex], vertexCount, instanceCount, firstVertex, firstInstance );
```
Drawing with an Indexed Buffer

vkCmdBindVertexBuffers( commandBuffer, firstBinding, bindingCount, vertexDataBuffers, vertexOffsets );

vkCmdBindIndexBuffer( commandBuffer, indexDataBuffer, indexOffset, indexType );

typedef enum VkIndexType
{
    VK_INDEX_TYPE_UINT16 = 0,    // 0 – 65,535
    VK_INDEX_TYPE_UINT32 = 1,    // 0 – 4,294,967,295
} VkIndexType;

vkCmdDrawIndexed( commandBuffer, indexCount, instanceCount, firstIndex, vertexOffset, firstInstance );

Indirect Drawing

vkCmdDrawIndirect( commandBuffer, buffer, offset, drawCount, stride );

typedef struct
VkDrawIndirectCommand
{
    uint32_t    vertexCount;
    uint32_t    instanceCount;
    uint32_t    firstVertex;
    uint32_t    firstInstance;
} VkDrawIndirectCommand;

Compare this with:

vkCmdDraw( CommandBuffers[nextimageIndex], vertexCount, instanceCount, firstVertex, firstInstance );
Indexed Indirect Drawing

```c
vkCmdDrawIndexedIndirect( commandBuffer, buffer, offset, drawCount, stride );
```

define struct
VkDrawIndexedIndirectCommand
{
    uint32_t    indexCount;
    uint32_t    instanceCount;
    uint32_t    firstIndex;
    int32_t     vertexOffset;
    uint32_t    firstInstance;
} VkDrawIndexedIndirectCommand;

Sometimes a point that is common to multiple faces has the same attributes, no matter what face it is in. Sometimes it doesn’t.

A color-interpolated cube like this actually has both. Point #7 above has the same color, regardless of what face it is in. However, Point #7 has 3 different normal vectors, depending on which face you are defining. Same with its texture coordinates.

Thus, when using index-ed buffer drawing, you need to create a new vertex struct if any of (position, normal, color, texCoords) changes from what was previously-stored at those coordinates.
The OBJ File Format – a triple-indexed way of Drawing

Note: The OBJ file format uses 1-based indexing for faces!