Vulkan.

Synchronization

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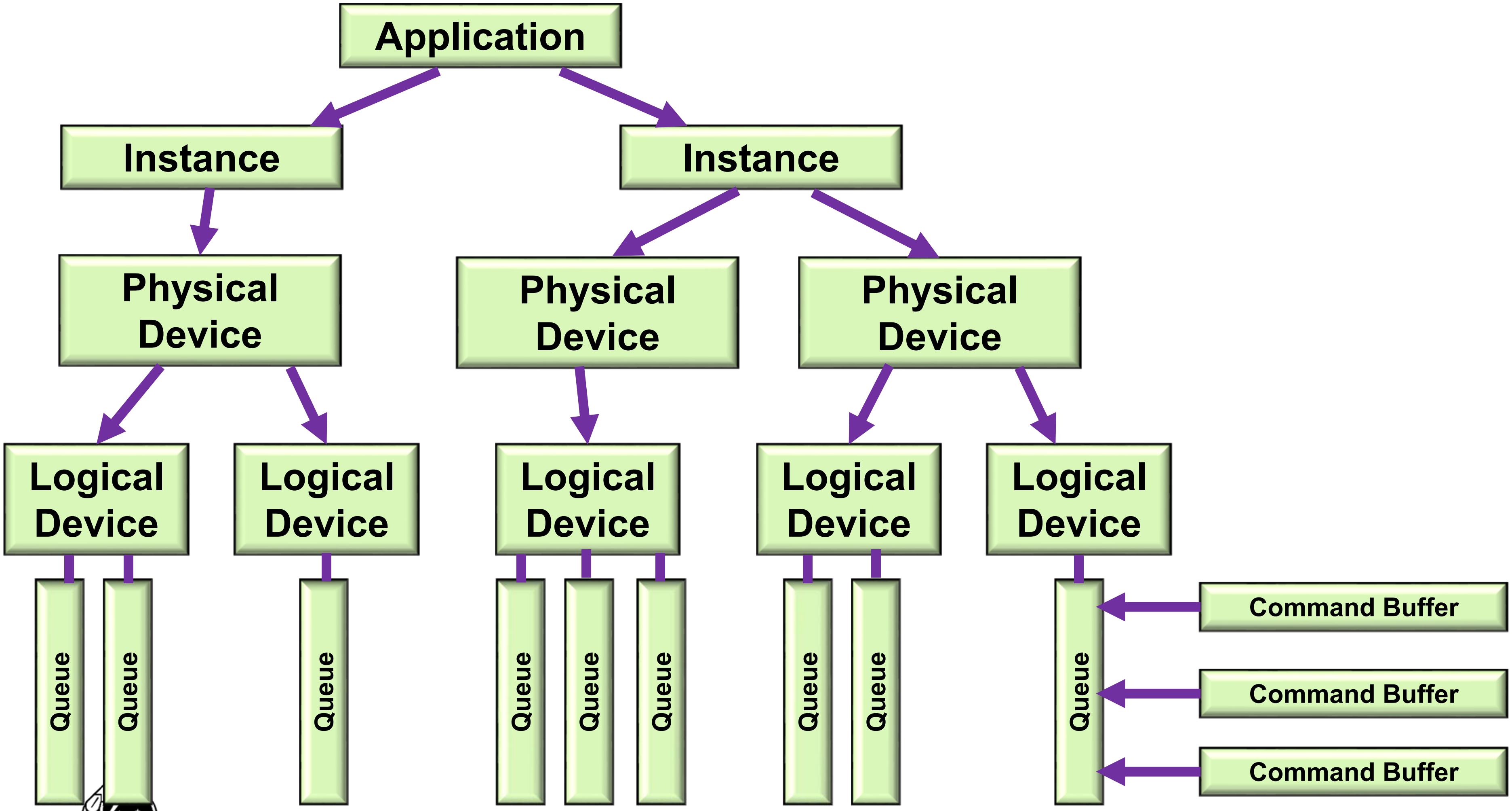
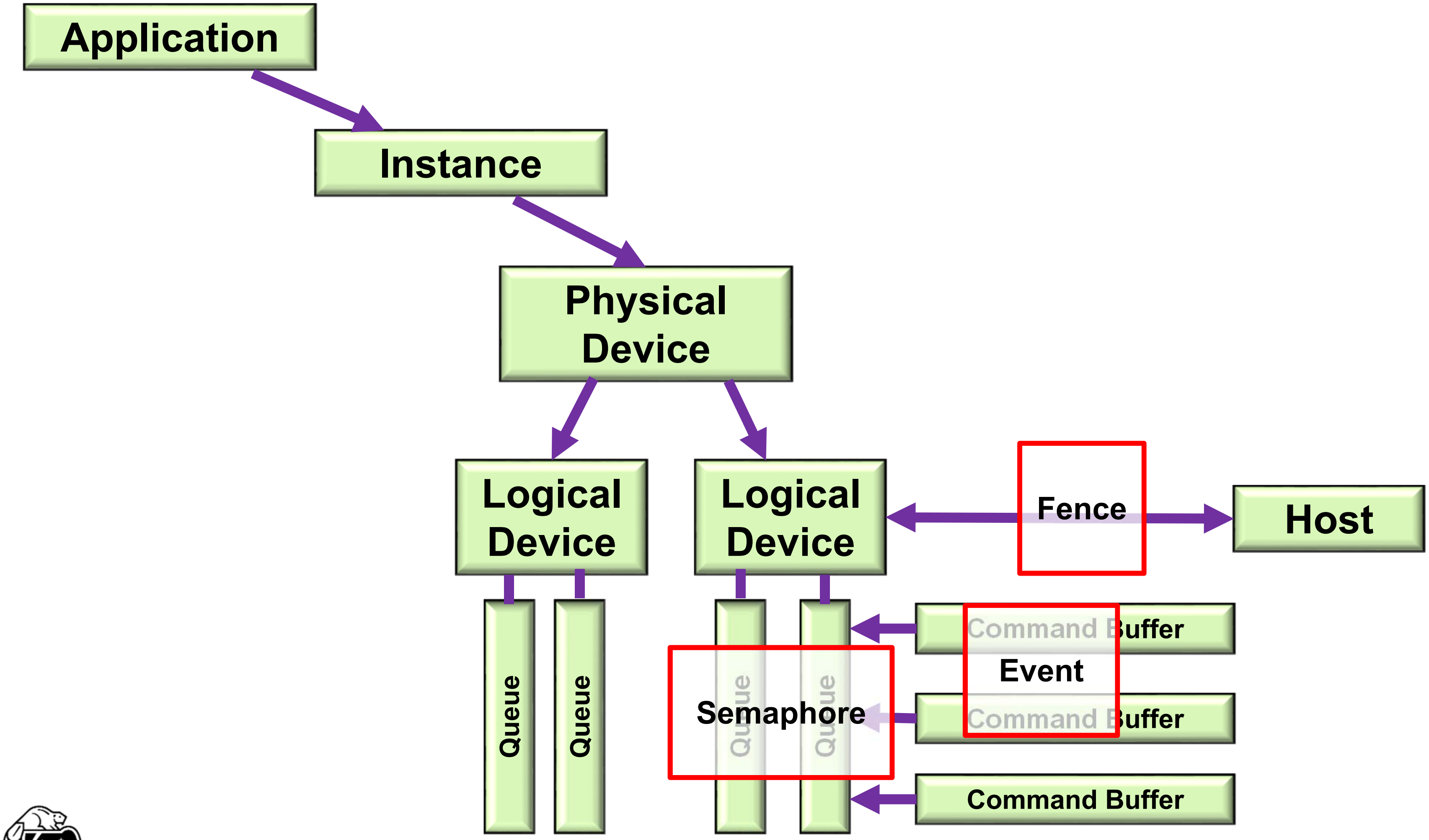
Remember the Overall Block Diagram?

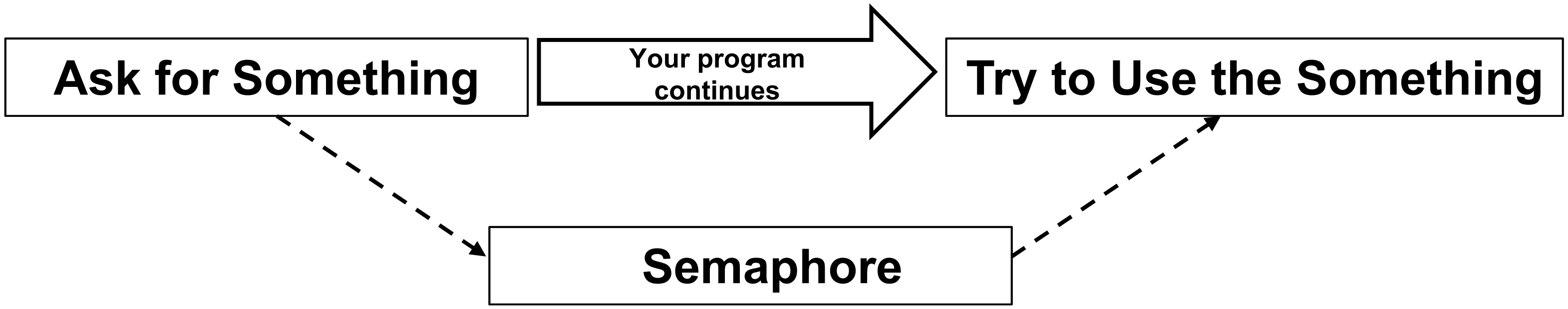


Vulkan Highlights: Overall Block Diagram



Semaphores

- Used to control readiness of resources within one queue or across different queues belonging to the same logical device
- You create them, and give them to a Vulkan function which sets them. Later on, you tell a Vulkan function to wait on this particular semaphore
- You don't end up setting, resetting, or checking the semaphore yourself
- Semaphores must be initialized ("created") before they can be used



Ask for Something

Your program continues

Try to Use the Something

Semaphore

Creating a Semaphore

```
VkSemaphoreCreateInfo                    vsci;
        vsci.sType = VK_STRUCTURE_TYPE_SEMAPHORE_CREATE_INFO;
        vsci.pNext = nullptr;
        vsci.flags = 0;;

VkSemaphore             semaphore;
result = vkCreateSemaphore( LogicalDevice, IN &vsci, PALLOCATOR, OUT &semaphore );
```

Semaphores Example during the Render Loop

```
VkSemaphore imageReadySemaphore;

VkSemaphoreCreateInfo                 vsci;
            vsci.sType = VK_STRUCTURE_TYPE_SEMAPHORE_CREATE_INFO;
            vsci.pNext = nullptr;
            vsci.flags = 0;

result = vkCreateSemaphore( LogicalDevice, IN &vsci, PALLOCATOR, OUT &imageReadySemaphore );

uint32_t nextImageIndex;
vkAcquireNextImageKHR( LogicalDevice, IN SwapChain, IN UINT64_MAX,
                                    IN imageReadySemaphore, IN VK_NULL_HANDLE, OUT &nextImageIndex );

       . . .

VkPipelineStageFlags waitAtBottom = VK_PIPELINE_STAGE_BOTTOM_OF_PIPE_BIT;
VkSubmitInfo                          vsi;
            vsi.sType = VK_STRUCTURE_TYPE_SUBMIT_INFO;
            vsi.pNext = nullptr;
            vsi.waitSemaphoreCount = 1;
            vsi.pWaitSemaphores = &imageReadySemaphore;
            vsi.pWaitDstStageMask = &waitAtBottom;
            vsi.commandBufferCount = 1;
            vsi.pCommandBuffers = &CommandBuffers[nextImageIndex];
            vsi.signalSemaphoreCount = 0;
            vsi.pSignalSemaphores = (VkSemaphore) nullptr;

result = vkQueueSubmit( presentQueue, 1, IN &vsi, IN renderFence );
```

Could be an array of semaphores

Fences

- Used to synchronize the application with commands submitted to a queue
- Announces that queue-submitted work is finished
- Much finer control than semaphores
- You can un-signal, signal, test or block-while-waiting

Fences

```
#define VK_FENCE_CREATE_UNSIGNALED_BIT          0

VkFenceCreateInfo                       vfci;
        vfci.sType = VK_STRUCTURE_TYPE_FENCE_CREATE_INFO;
        vfci.pNext = nullptr;
        vfci.flags = VK_FENCE_CREATE_UNSIGNALED_BIT;            // = 0
                // VK_FENCE_CREATE_SIGNALED_BIT is only other option

VkFence             fence;
result = vkCreateFence( LogicalDevice, IN &vfci, PALLOCATOR, OUT &fence );


        , , ,

// returns right away:
result = vkGetFenceStatus( LogicalDevice, IN fence );
                // result = VK_SUCCESS means it has signaled
                // result = VK_NOT_READY means it has not signaled


// blocks:
result = vkWaitForFences( LogicalDevice, 1, IN &fence, waitForAll, timeout );
               // waitForAll = VK_TRUE:   wait for all fences in the list
               // waitForAll = VK_FALSE: wait for any one fence in the list
               // timeout is a uint64_t timeout in nanoseconds  (could be 0, which means to return immediately)
              // timeout can be up to UINT64_MAX  = 0xffffffffffffffff (= 580+ years)
              // result = VK_SUCCESS means it returned because a fence  (or all fences) signaled
              // result = VK_TIMEOUT means it returned because the timeout was exceeded
```

Could be an array of fences

Fence Example

```
VkFence renderFence;
vkCreateFence( LogicalDevice, &vfci, PALLOCATOR, OUT &renderFence );

VkPipelineStageFlags waitAtBottom = VK_PIPELINE_STAGE_BOTTOM_OF_PIPE_BIT;

VkQueue presentQueue;
vkGetDeviceQueue( LogicalDevice, FindQueueFamilyThatDoesGraphics( ), 0, OUT &presentQueue );

VkSubmitInfo                    vsi;
        vsi.sType = VK_STRUCTURE_TYPE_SUBMIT_INFO;
        vsi.pNext = nullptr;
        vsi.waitSemaphoreCount = 1;
        vsi.pWaitSemaphores = &imageReadySemaphore;
        vsi.pWaitDstStageMask = &waitAtBottom;
        vsi.commandBufferCount = 1;
        vsi.pCommandBuffers = &CommandBuffers[nextImageIndex];
        vsi.signalSemaphoreCount = 0;
        vsi.pSignalSemaphores = (VkSemaphore) nullptr;

result = vkQueueSubmit( presentQueue, 1, IN &vsi, IN renderFence );

     . . .

result = vkWaitForFences( LogicalDevice, 1, IN &renderFence, VK_TRUE, UINT64_MAX );

     . . .

result = vkQueuePresentKHR( presentQueue, IN &vpi );
```

Events

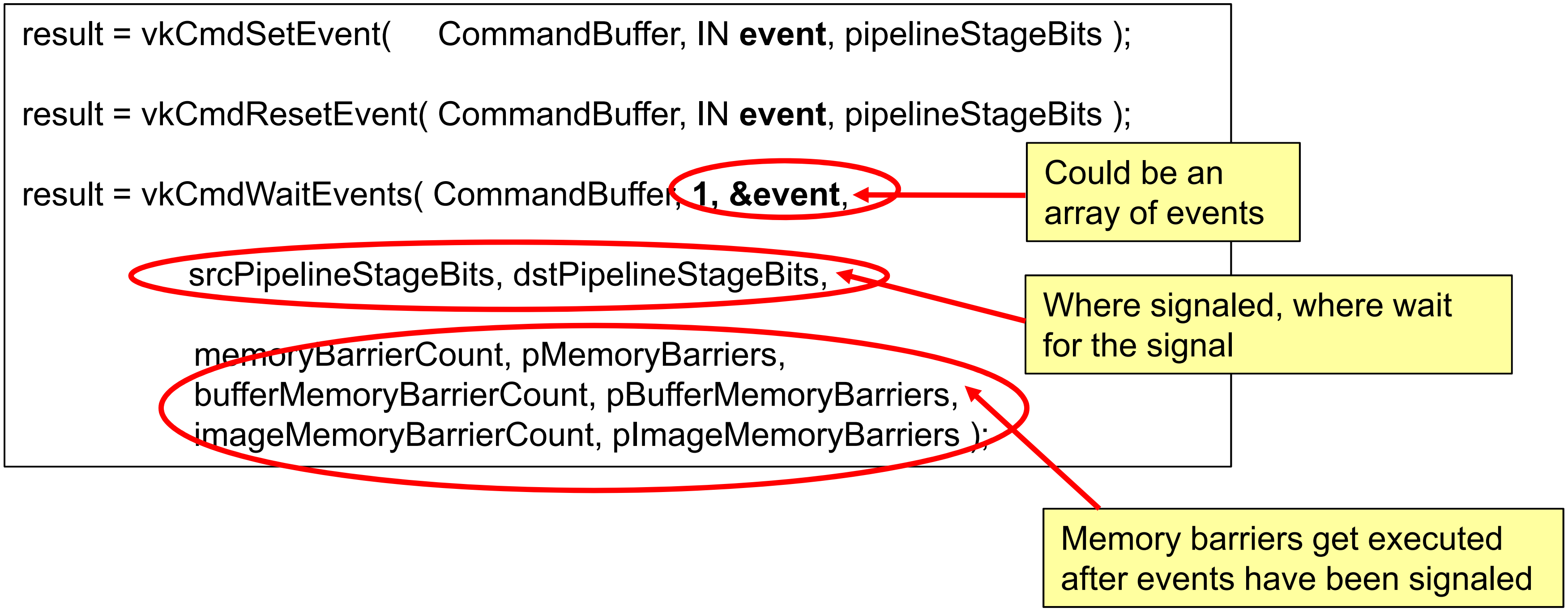
- Events provide even finer-grained synchronization
- Events are a primitive that can be signaled by the host or the device
- Can even signal at one place in the pipeline and wait for it at another place in the pipeline
- Signaling in the pipeline means “signal as the last piece of this draw command passes that point in the pipeline”.
- You can signal, un-signal, or test from a vk function or from a vkCmd function
- Can wait from a vkCmd function

Controlling Events from the Host

```
VkEventCreateInfo                                   veci;
        veci.sType = VK_STRUCTURE_TYPE_EVENT_CREATE_INFO;
        veci.pNext = nullptr;
        veci.flags = 0;

VkEvent             event;
result = vkCreateEvent( LogicalDevice, IN &veci, PALLOCATOR, OUT &event );

result = vkSetEvent( LogicalDevice, IN event );

result = vkResetEvent( LogicalDevice, IN event );

result = vkGetEventStatus( LogicalDevice, IN event );
                // result = VK_EVENT_SET: signaled
                // result = VK_EVENT_RESET: not signaled
```

Note: the CPU cannot *block* waiting for an event, but it can test for one

Controlling Events from the Device



```
result = vkCmdSetEvent(     CommandBuffer, IN event, pipelineStageBits );

result = vkCmdResetEvent( CommandBuffer, IN event, pipelineStageBits );

result = vkCmdWaitEvents( CommandBuffer, 1, &event,

            srcPipelineStageBits, dstPipelineStageBits,

            memoryBarrierCount, pMemoryBarriers,
            bufferMemoryBarrierCount, pBufferMemoryBarriers,
            imageMemoryBarrierCount, pImageMemoryBarriers );
```

Could be an array of events

Where signaled, where wait for the signal

Memory barriers get executed after events have been signaled

Note: the GPU cannot *test* for an event, but it can block waiting for one