The Swap Chain
What is a Swap Chain?

In Vulkan, the Swap Chain manages one or more image objects that form a sequence of images that can be drawn into and presented to the user for viewing.

Swap Chains are tightly coupled to the window system.

After creating the Swap Chain in the first place, the process for using the Swap Chain is:

1. Ask the Swap Chain for an image
2. Render into it via the Command Buffer and a Queue
3. Return the image to the Swap Chain for presentation
4. Present the image to the viewer
What is a Swap Chain?

Because it has the word “chain” in it, let’s try to visualize the Swap Chain as a physical chain.

A bicycle chain isn’t far off. A bicycle chain goes around and around, each link in the chain taking its turn on the gear teeth, off the gear teeth, on, off, on, etc.

Because the Swap Chain is actually a ring buffer, the images in a Swap Chain go around and around too, each image taking its turn being drawn into, being presented, drawn into, being presented etc.

In the same way that bicycle chain links are “re-used”, Swap Chain images get re-used too.
What is a Swap Chain?
Creating a Swap Chain

```plaintext
vkCreateSwapchain( )

VkSwapchainCreateInfo
  surface
  imageFormat
  imageColorSpace
  imageExtent
  imageArrayLayers
  imageUsage
  imageSharingMode
  preTransform
  compositeAlpha
  presentMode
  clipped

vkGetDevicePhysicalSurfaceCapabilities( )

VkSurfaceCapabilities
  minImageCount
  maxImageCount
  currentExtent
  minImageExtent
  maxImageExtent
  maxImageArrayLayers
  supportedTransforms
  currentTransform
  supportedCompositeAlpha

vkGetSwapChainImages( )

vkCreateImageView( )
```
Creating a Swap Chain

```
VkSurfaceCapabilitiesKHR vsc;
vkGetPhysicalDeviceSurfaceCapabilitiesKHR( PhysicalDevice, Surface, OUT &vsc );
VkExtent2D surfaceRes = vsc.currentExtent;

VkSwapchainCreateInfoKHR vscci;
    vscci.sType = VK_STRUCTURE_TYPE_SWAPCHAIN_CREATE_INFO_KHR;
    vscci.pNext = nullptr;
    vscci.flags = 0;
    vscci.surface = Surface;
    vscci.minImageCount = 2;               // double buffering
    vscci.imageFormat = VK_FORMAT_B8G8R8A8_UNORM;
    vscci.imageColorSpace = VK_COLORSPACE_SRGB_NONLINEAR_KHR;
    vscci.imageExtent.width = surfaceRes.width;
    vscci.imageExtent.height = surfaceRes.height;
    vscci.imageUsage = VK_IMAGE_USAGE_COLOR_ATTACHMENT_BIT;
    vscci.preTransform = VK_SURFACE_TRANSFORM_IDENTITY_BIT_KHR;
    vscci.compositeAlpha = VK_COMPOSITE_ALPHA_OPAQUE_BIT_KHR;
    vscci.imageArrayLayers = 1;
    vscci.imageSharingMode = VK_SHARING_MODE_EXCLUSIVE;
    vscci.queueFamilyIndexCount = 0;
    vscci.pQueueFamilyIndices = (const uint32_t *)nullptr;
    vscci.presentMode = VK_PRESENT_MODE_MAILBOX_KHR;
    vscci.oldSwapchain = VK_NULL_HANDLE;
    vscci.clipped = true;

result = vkCreateSwapchainKHR( LogicalDevice, IN &vscci, PALLOCATOR, OUT &SwapChain );
```
Creating the Swap Chain Images and Image Views

```c
uint32_t imageCount; // # of display buffers – 2? 3?
result = vkGetSwapchainImagesKHR( LogicalDevice, IN SwapChain, OUT &imageCount, (VkImage *)nullptr );

PresentImages = new VkImage[ imageCount ];
result = vkGetSwapchainImagesKHR( LogicalDevice, SwapChain, OUT &imageCount, PresentImages );

// present views for the double-buffering:

PresentImageViews = new VkImageView[ imageCount ];

for( unsigned int i = 0; i < imageCount; i++ )
{
    VkImageViewCreateInfo vivci;
    vivci.sType = VK_STRUCTURE_TYPE_IMAGE_VIEW_CREATE_INFO;
    vivci.pNext = nullptr;
    vivci.flags = 0;
    vivci.viewType = VK_IMAGE_VIEW_TYPE_2D;
    vivci.format = VK_FORMAT_B8G8R8A8_UNORM;
    vivci.components.r = VK_COMPONENT_SWIZZLE_R;
    vivci.components.g = VK_COMPONENT_SWIZZLE_G;
    vivci.components.b = VK_COMPONENT_SWIZZLE_B;
    vivci.components.a = VK_COMPONENT_SWIZZLE_A;
    vivci.subresourceRange.aspectMask = VK_IMAGE_ASPECT_COLOR_BIT;
    vivci.subresourceRange.baseMipLevel = 0;
    vivci.subresourceRange.levelCount = 1;
    vivci.subresourceRange.baseArrayLayer = 0;
    vivci.subresourceRange.layerCount = 1;
    vivci.image = PresentImages[ i ];

    result = vkCreateImageView( LogicalDevice, IN &vivci, PALLOCATOR, OUT &PresentImageViews[ i ] );
}
```

Rendering into the Swap Chain, I

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

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

uint32_t nextImageIndex;
uint64_t timeout = UINT64_MAX;
vkAcquireNextImageKHR( LogicalDevice, IN SwapChain, IN timeout, IN imageReadySemaphore, 
    IN VK_NULL_HANDLE, OUT &nextImageIndex );

result = vkBeginCommandBuffer( CommandBuffers[ nextImageIndex ], IN &vcbbi );

vkCmdBeginRenderPass( CommandBuffers[ nextImageIndex ], IN &vrpbi, 
    IN VK_SUBPASS_CONTENTS_INLINE );

vkCmdBindPipeline( CommandBuffers[ nextImageIndex ], VK_PIPELINE_BIND_POINT_GRAPHICS, GraphicsPipeline );

vkCmdEndRenderPass( CommandBuffers[ nextImageIndex ] );
vkEndCommandBuffer( CommandBuffers[ nextImageIndex ] );
```
Rendering into the Swap Chain, II

VkFenceCreateInfo vfci;
    vfci.sType = VK_STRUCTURE_TYPE_FENCE_CREATE_INFO;
    vfci.pNext = nullptr;
    vfci.flags = 0;

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

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 = &SemaphoreRenderFinished;

result = vkQueueSubmit( presentQueue, 1, IN &vsi, IN renderFence );  // 1 = submitCount
result = vkWaitForFences( LogicalDevice, 1, IN &renderFence, VK_TRUE, UINT64_MAX );

VkPresentInfoKHR vpi;
  vpi.sType = VK_STRUCTURE_TYPE_PRESENT_INFO_KHR;
  vpi.pNext = nullptr;
  vpi.waitSemaphoreCount = 0;
  vpi.pWaitSemaphores = (VkSemaphore *)nullptr;
  vpi.swapchainCount = 1;
  vpi.pSwapchains = &SwapChain;
  vpi.pImageIndices = &nextImageIndex;
  vpi.pResults = (VkResult *)nullptr;

result = vkQueuePresentKHR( presentQueue, IN &vpi );