# Presentation

Surfaces, Swapchains, and ImageViews

# More Extension!

- As mentioned previously: Displaying images to a window is not native to Vulkan. Requires extensions.

- This also includes swapping out images like in a Double/Triple Buffer.
  - This means the common method of drawing to one image while another is displayed, and then swapping them at an appropriate time to display the updated image.

- To do this we need two things:
  - Swapchain: Complex object that handles retrieval and updating of images being displayed, or yet to be displayed.
  - Surface: An interface between the window and an image in the swapchain.

# Surface

- Will act as an interface between the window created by GLFW and a Vulkan defined image in the Swapchain.

- Surface will need to be created specifically for the window of the system we're using.

- Could define this manually, but would make things complex when going cross-platform!

- Fortunately, GLFW has a built-in function that returns an adequate surface for the current system being used.

- glfwCreateWindowSurface(…)

# The "Presentation Queue"

- In order to present a new Swapchain image to our surface, we need a queue that can handle present operations.

- This is not really a type of queue, but a feature that some have.

- Graphics queues usually have the required feature.

- This means our Graphics queue and Presentation queue will usually be the same queue!

# The Swapchain

- Another extension. Will need to be checked for compatibility.

- The Swapchain is a group of images that can be drawn to and presented.

- The object is set up so it can be queried to get a new image to be drawn to, and then presented.

- This requires a lot of synchronisation… which we will cover in a later video!

- The Swapchain has a few parts that need to be set up.

# Creating the Swapchain

- **A Swapchain has 3 major parts:**
  - **Surface Capabilities:** What the surface is capable of handling (e.g. image size)
  - **Surface Format:** The format of the surface the Swapchain will present to (e.g. RGB)
  - **Presentation Mode:** The order and timing of images being presented to the surface.
- The Swapchain settings are largely based on the Surface. We query the Surface for these parts to ensure compatibility.
- The "Presentation Mode" can be hard to understand, so let's explore it in more detail...

# Presentation Mode

- Presentation Modes are the order and timing of images being presented to the Surface.

- There are 4 Presentation Modes and 2 of them are often considered undesirable due to the risk of introducing "tearing".

- At any one time, there will be one image present at the Surface that is being drawn to the screen.

- First, some information about how monitors work:

  - Monitors draw starting at the top-left pixel, and then drawing to the screen row-by-row.

  - When the image completes, the screen is then cleared to start drawing again. The period of time AFTER this clear, and BEFORE it starts drawing again, is known as a "Vertical Blank Interval" or simply a "Vertical Blank". This is usually the best time to replace the Surface image.

# Presentation Mode (cont.)

- **VK_PRESENT_MODE_IMMEDIATE_KHR**: In this mode, the Surface image will be replaced *immediately* after the next image to be displayed has finished rendering.

- This can be an issue! Our Surface may only be halfway through drawing to the screen when we replace it, causing the second half to be a different image. This results in "tearing".
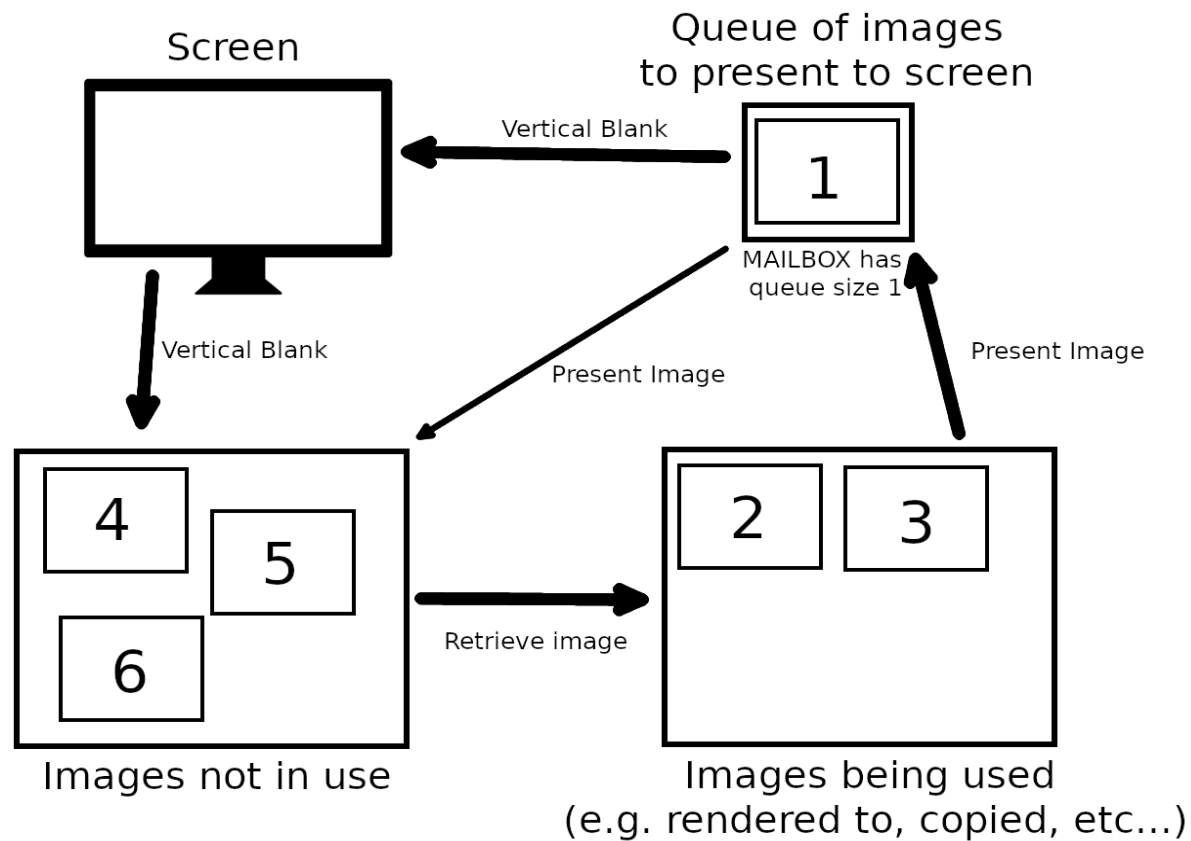
# Presentation Mode (cont.)

- Example of "tearing" in a video game.

# Presentation Mode (cont.)

- **VK_PRESENT_MODE_MAILBOX_KHR**: Images ready to present are added to a queue of size 1. The Surface uses this image only at a Vertical Blank to avoid tearing.

- If a new image is sent to the queue to be presented, whatever is currently in the queue is discarded and becomes a vacant image ready to be drawn to again.
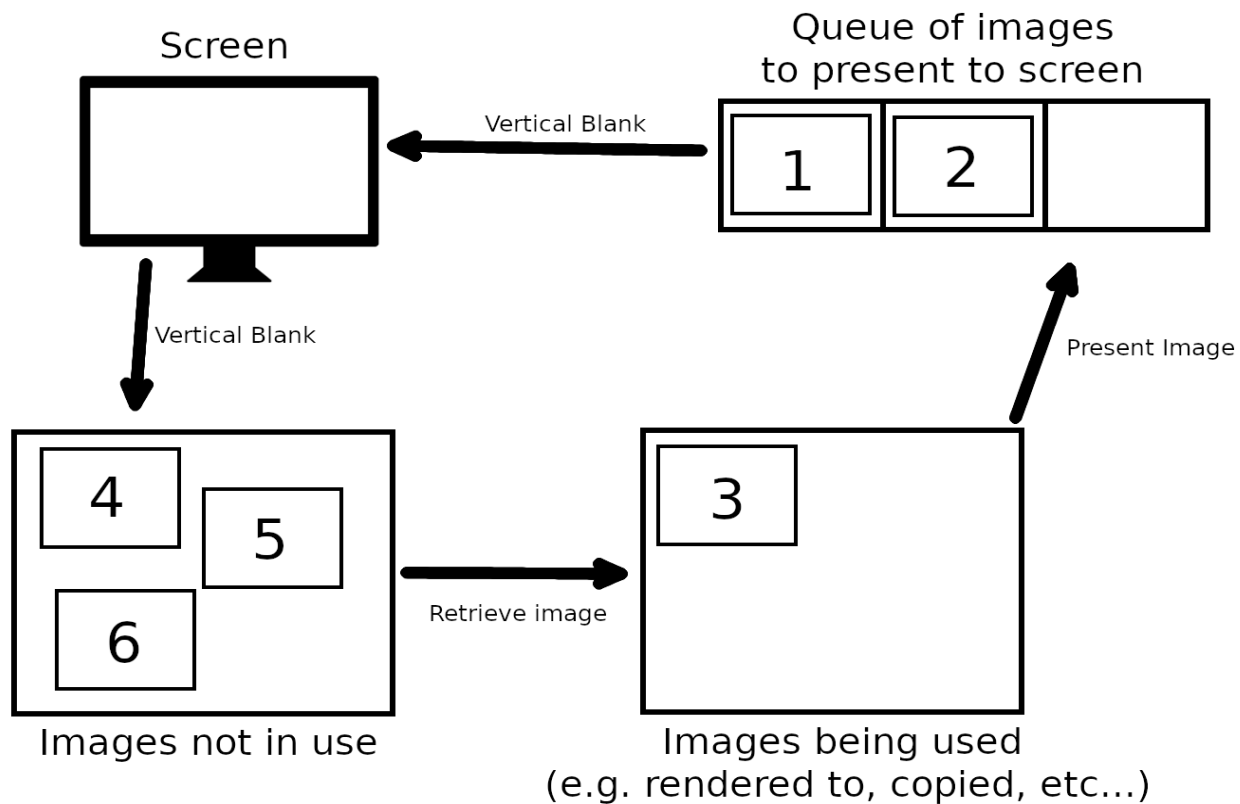
- This can be hard to imagine… Let's look at a diagram!

# VK_PRESENT_MODE_MAILBOX_KHR

Screen

Queue of images
to present to screen

Vertical Blank

1

MAILBOX has
queue size 1

Vertical Blank

Present Image

Present Image

4

5

6

Images not in use

2

3

Retrieve image

Images being used
(e.g. rendered to, copied, etc...)

# Presentation Mode (cont.)

- **VK_PRESENT_MODE_FIFO_KHR**: Images ready to present are added to a queue of a certain size. They are removed one at a time at each Vertical Blank, so there is no tearing.

- If a new image is sent to the queue to be presented, but the queue is full, the program will wait.

- If the queue is empty when the next Vertical Blank occurs, it will redraw the image currently held and check again at the next Vertical Blank.

# VK_PRESENT_MODE_FIFO_KHR

Screen

Queue of images
to present to screen

Vertical Blank

| 1 | 2 | |

Vertical Blank

Present Image

| 4 | 5 |
| 6 | |

Retrieve image

| 3 | |

Images not in use

Images being used
(e.g. rendered to, copied, etc...)

# Presentation Mode (cont.)

- VK_PRESENT_MODE_FIFO_RELAXED_KHR: This mode works the same as FIFO mode, except for the situation where there are no images on the queue during a Vertical Blank.

- If the presentation queue is empty during a Vertical Blank, it will start acting like Immediate mode.

- The next image placed on to the presentation queue will no longer wait for a Vertical Blank. It will instead be passed straight to the surface, like in Immediate mode. This will cause tearing.

- After, it will return to FIFO mode.

# Images and Image Views

- When the Swapchain is created, it will automatically create a set of images to be used by the Swapchain.

- Since we will be drawing to them, we need access to them. To do this, the Swapchain can be queried and an array of the images can be returned.

- However, these images can't be used directly since they are just the raw image.

- An "ImageView" type can be created to interface with an image.

- An ImageView simply describes how to read an image (e.g. 2D or 3D addresses, format, etc) and what part of the image to read (colour channels, mip levels, etc).

- Later on, we will use these ImageViews when drawing to and presenting our images.

# Summary

- Swap Chains and Surfaces are extensions.

- Surfaces are an interface between the window and the Swapchain images. GLFW can provide the necessary extension names.

- Swapchains are complex objects containing a list of images and procedures for the ordering and timing of image presentation.

- There are 4 modes of presenting images, but only VK_PRESENT_MODE_MAILBOX_KHR and VK_PRESENT_MODE_FIFO_KHR don't risk tearing.

- Swapchain images can be retrieved, and Image Views can be created to interface with the images for drawing/presentation.

See you next video!