SIGGRAPH2015

Xroads of Discovery

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The 42nd International Conference and Exhibition
on Computer Graphics and Interactive Techniques

VALVE

Porting Source 2 to Vulkan

Dan Ginsburg
Valve

Summary

- Source 2 Overview
- Porting to Vulkan
  - Shaders and Pipelines
  - Command Buffers
  - Memory Management
  - Descriptor Sets

Source 2 Overview

Source 2

- OpenGL, DX9, DX11, Vulkan
- Windows, Linux, Mac
- Dota 2 Reborn

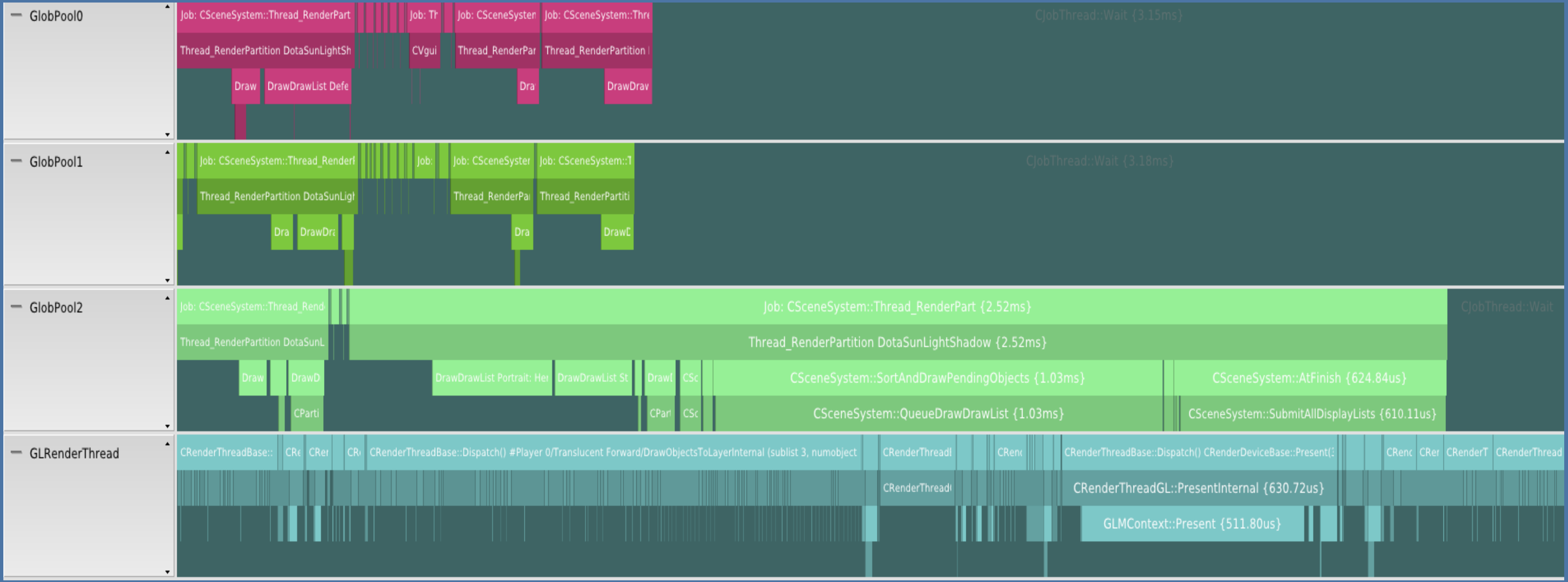
Heavy Damage

Use a Salve to heal. Taking damage will cancel the healing effect

Source 2 Rendering

- DX11-like rendersystem abstraction
- Multithreaded
  - DX9/GL: software command buffers
  - DX11: deferred contexts
  - Single submission thread

Source 2 Rendering (GL)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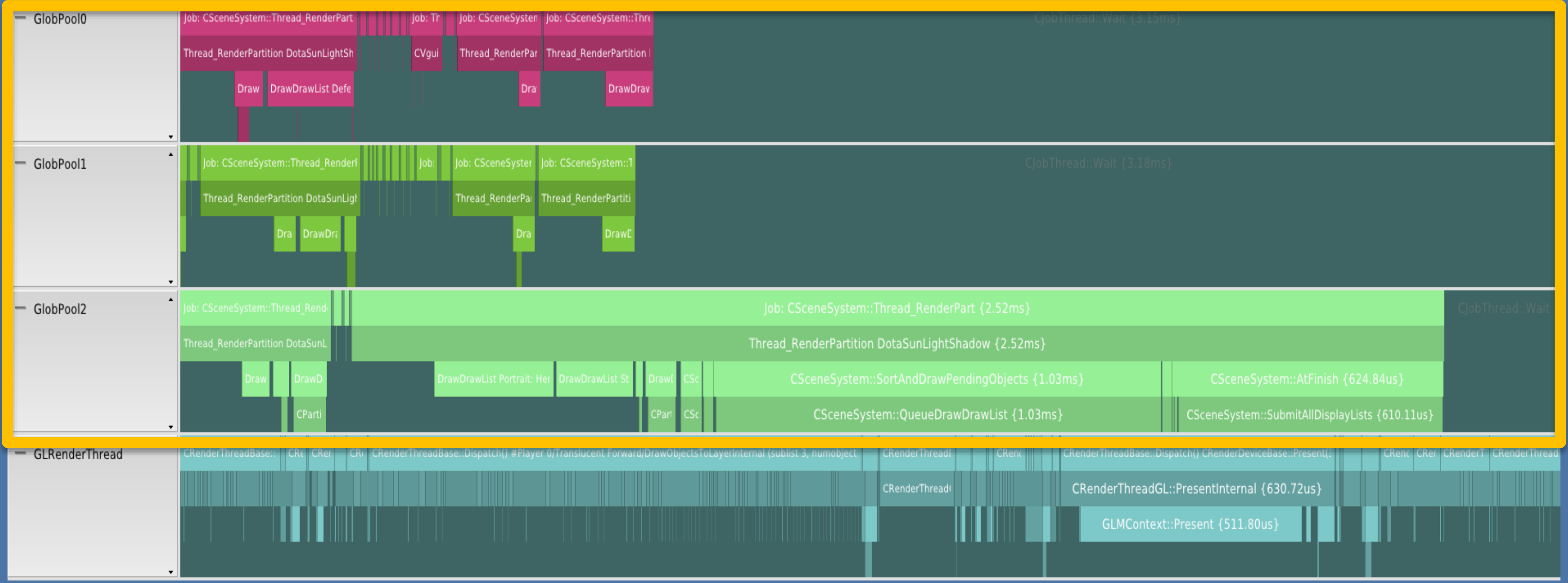
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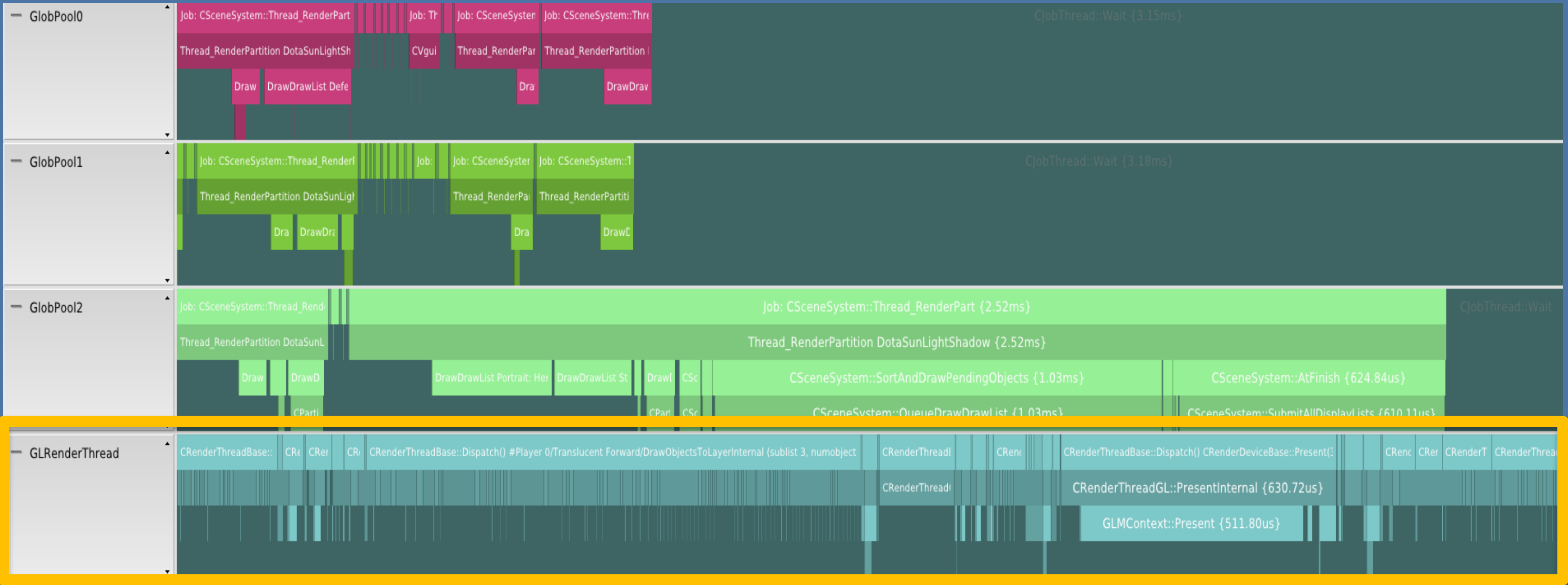
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Source 2 Vulkan Port

- Started with GL and DX11 renderer
  - DX11 deferred contexts mapped well to Vulkan command buffers
  - Leveraged GLSL shader conversion

Shaders and Pipelines

Porting Shaders to Vulkan

- HLSL -> GLSL
  - See: *Moving Your Games to OpenGL, Steam Dev Days 2014*
- GLSL -> SPIR-V
  - Descriptor set layout qualifiers to GLSL
  - Open source glslang SPIR-V backend
  - SPVremapper for compression
  - *https://github.com/KhronosGroup/glslang*

Pipeline State Objects (PSOs)

- Each thread caches pipeline state
- Global pipeline manager
  - PSO Map
  - Pending and current
    - Reduces mutexing

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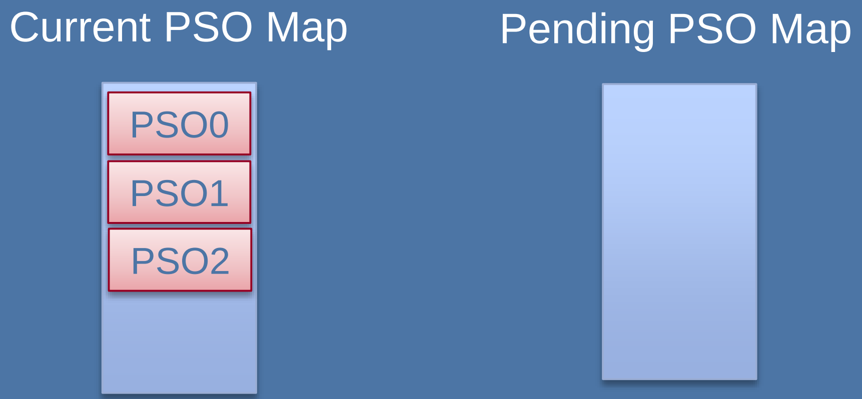

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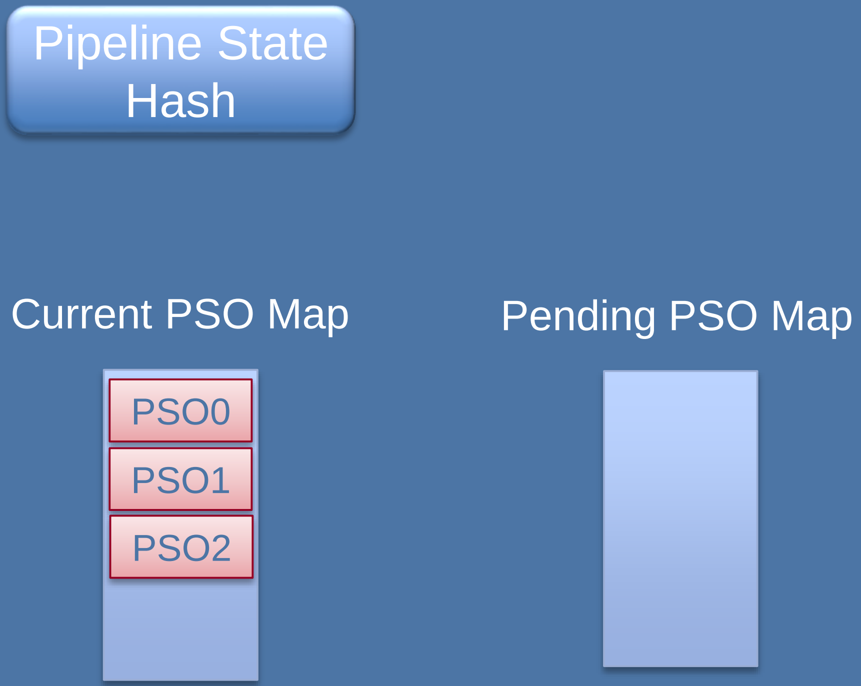

Pipeline State Hash

Current PSO Map

Pending PSO Map

PSO0

PSO1

PSO2

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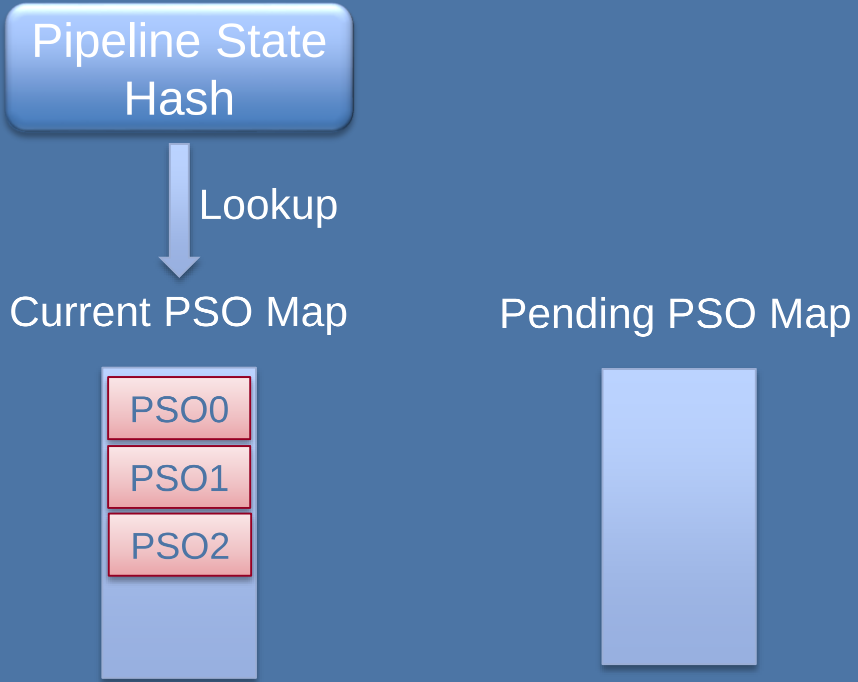

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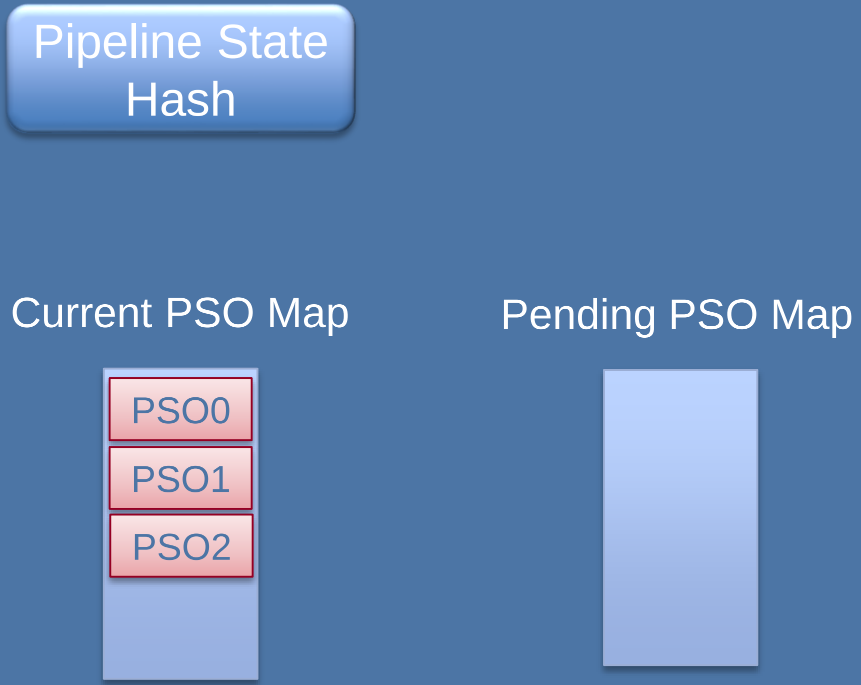

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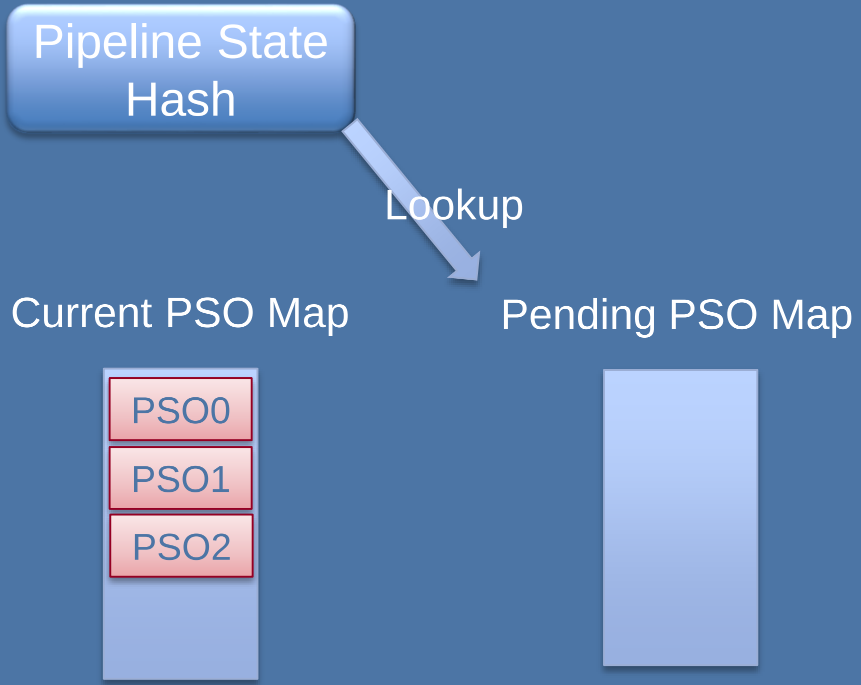

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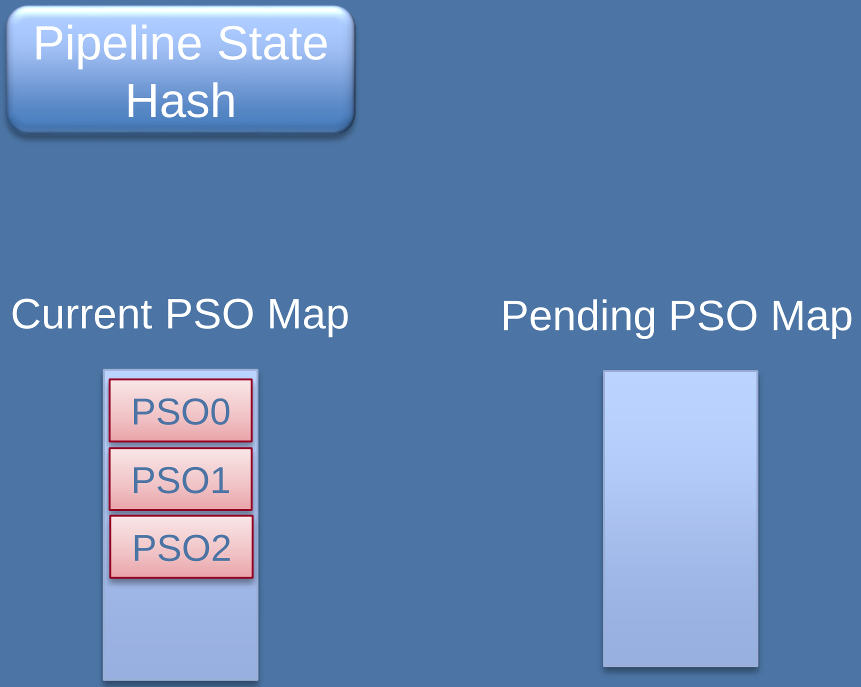

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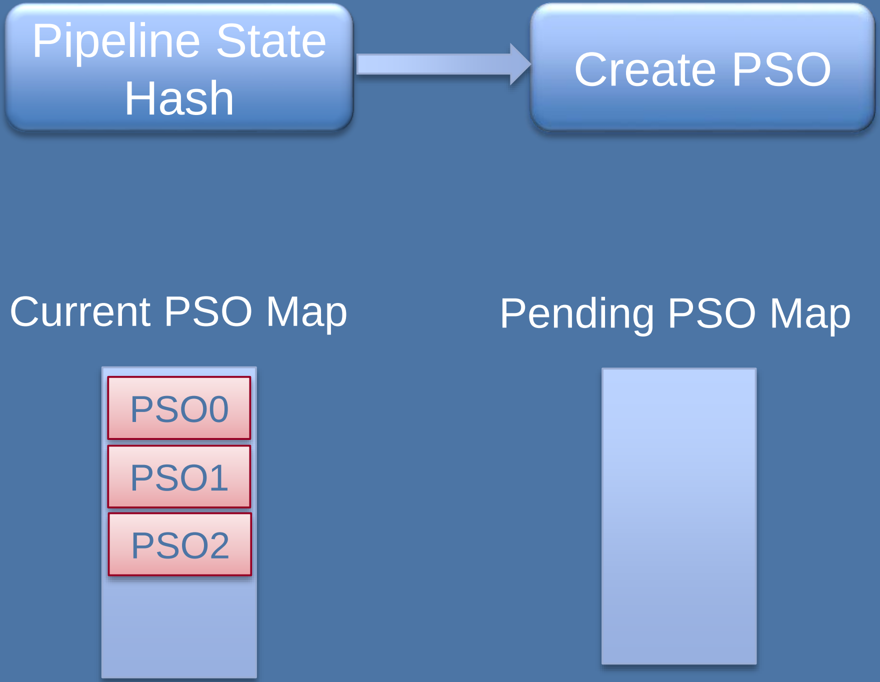

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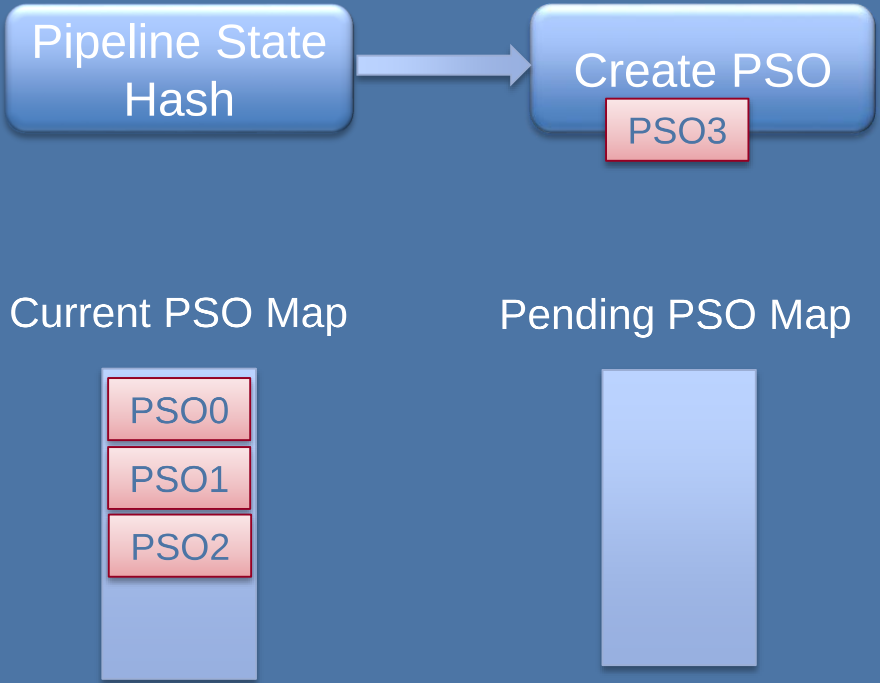

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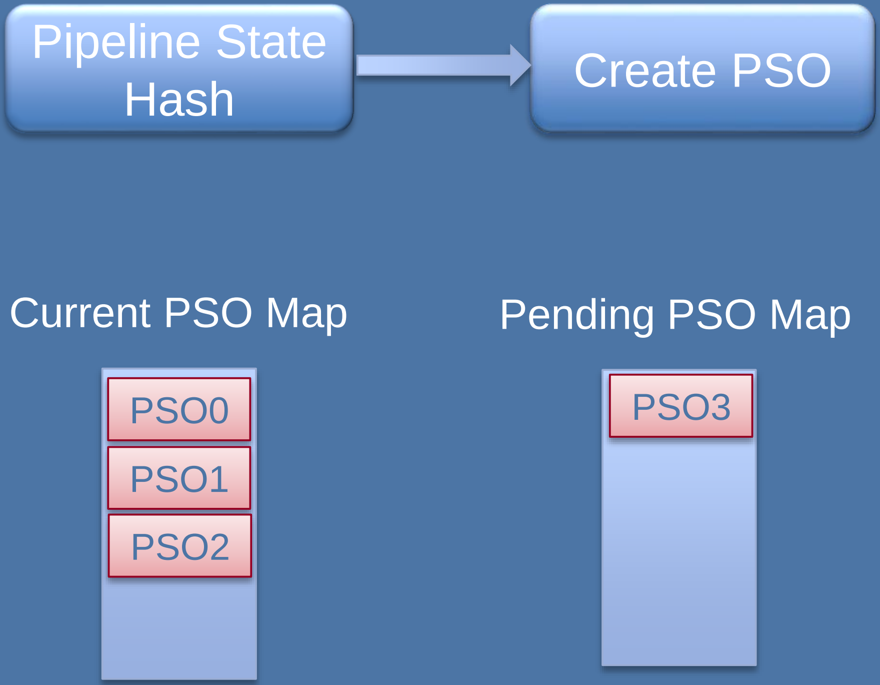

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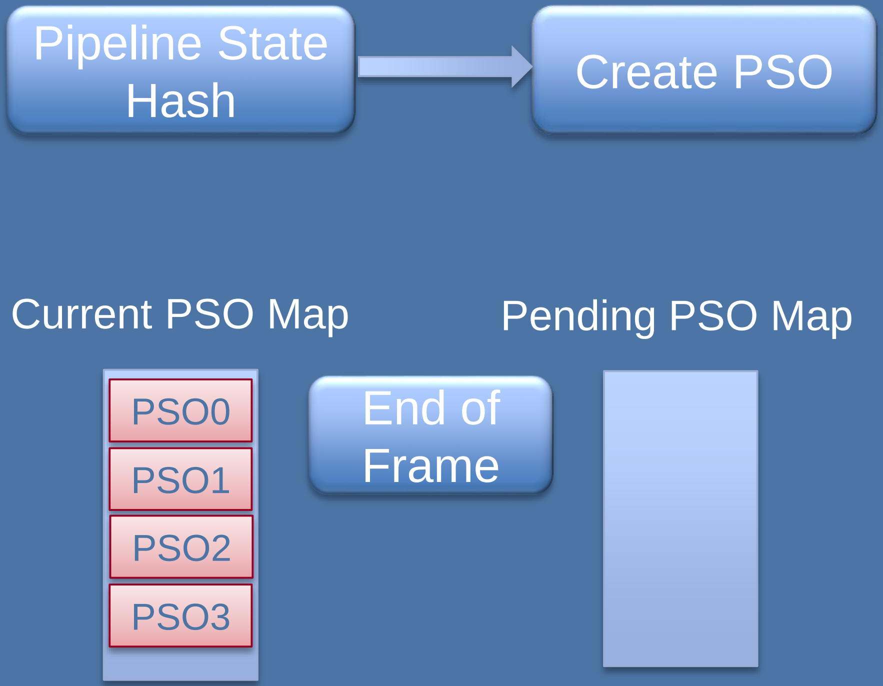

Pipeline State Hash

Create PSO

Current PSO Map

Pending PSO Map

PSO0

PSO1

PSO2

PSO3

End of Frame

Command Buffers

Command Buffers

- Used where DX11 deferred contexts were used
- Each thread builds command buffer
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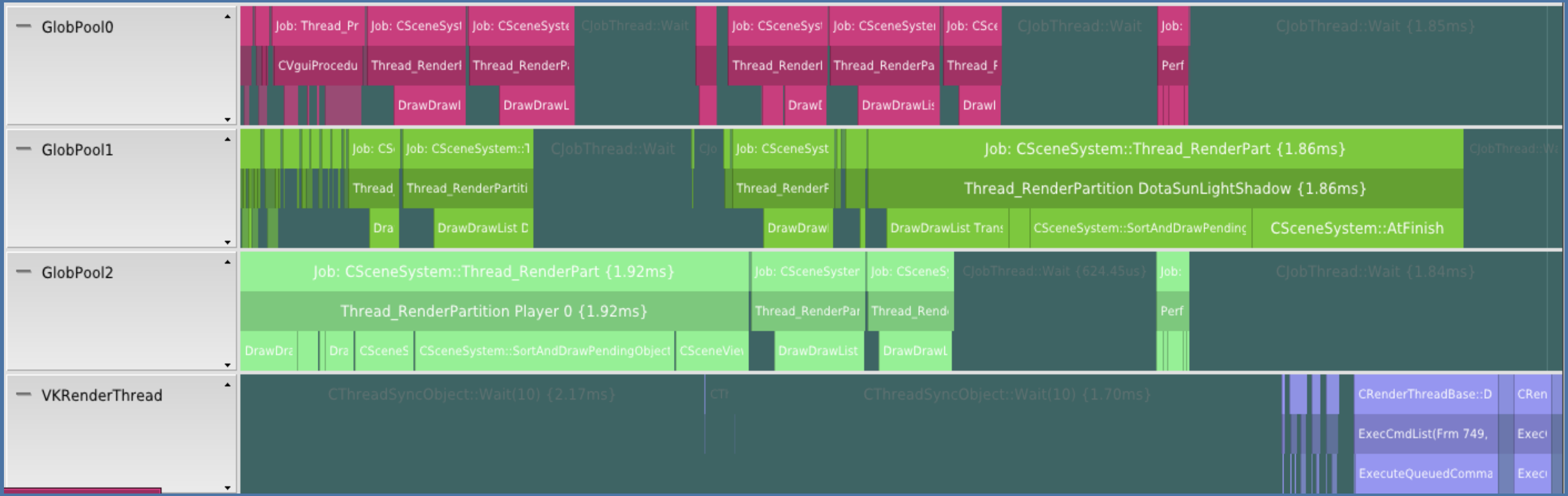

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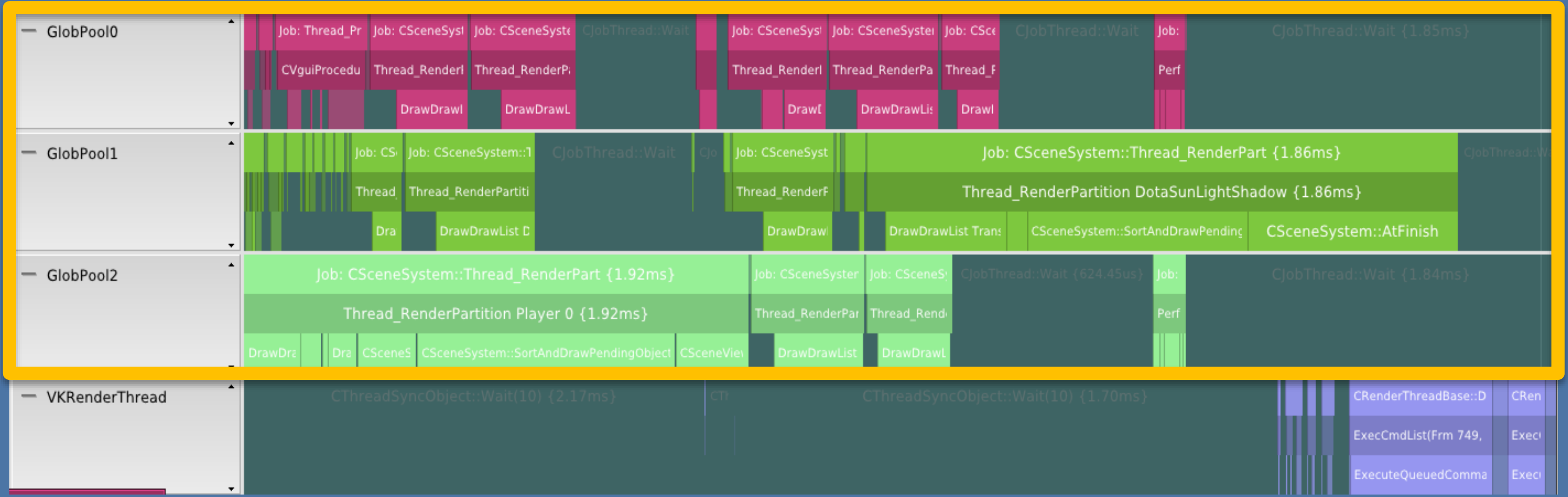

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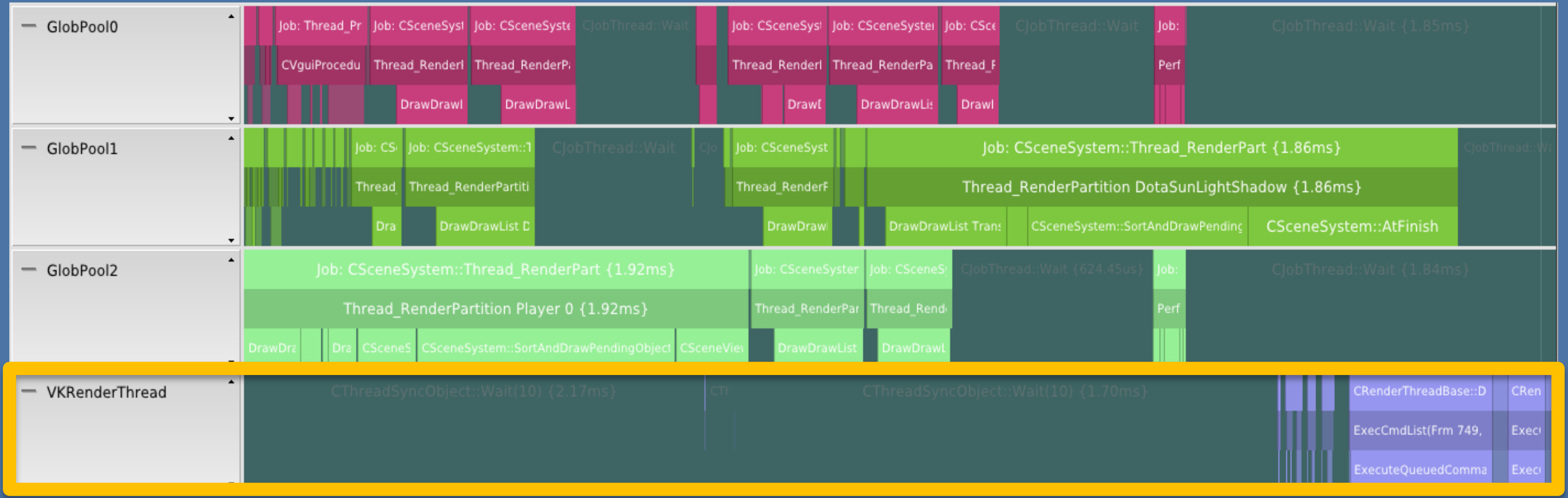


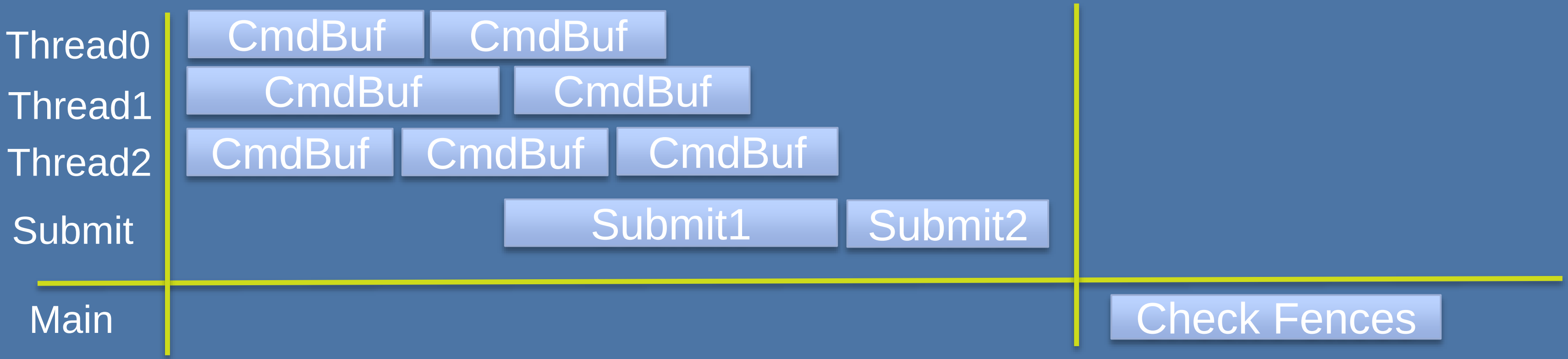
Command Buffers

- Recycled within per-thread pools

Thread 0 CommandPool

Thread 1 CommandPool

Thread 2 CommandPool



Thread0 CmdBuf CmdBuf

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Submit Submit1 Submit2

Main Check Fences

Command Buffers

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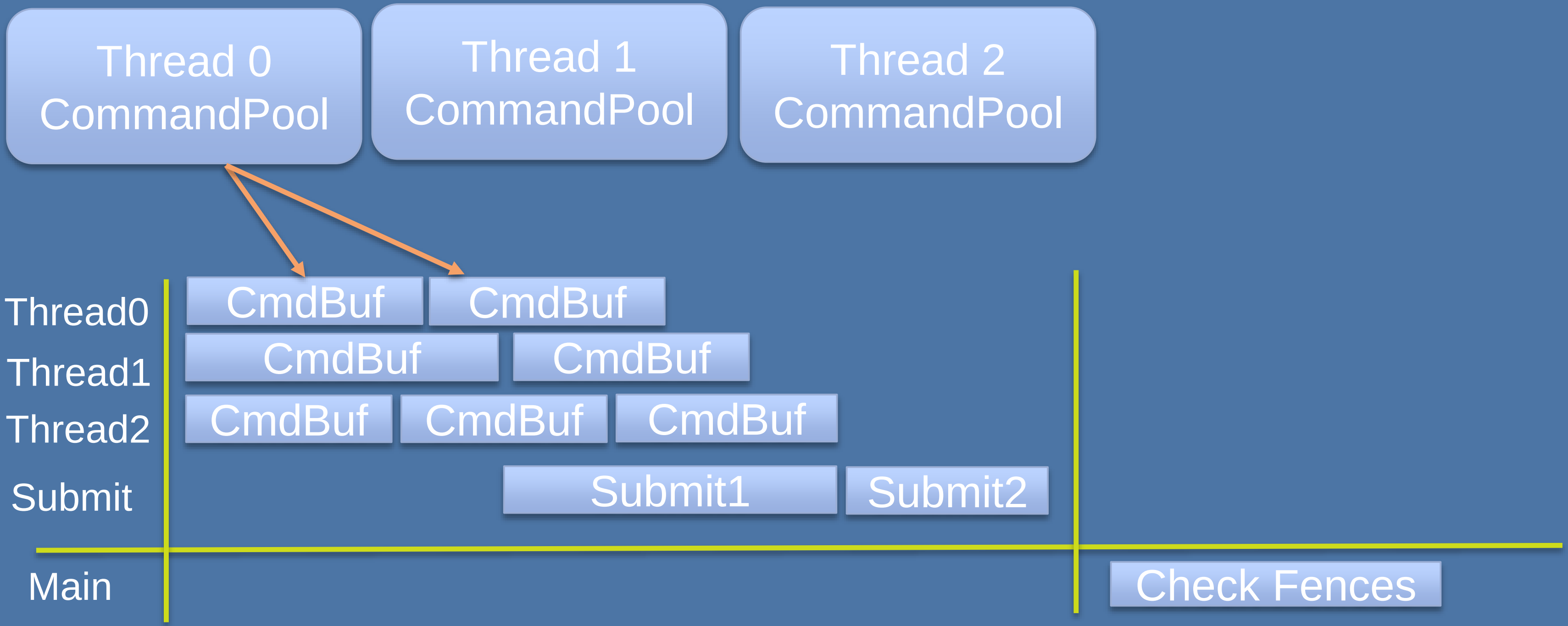

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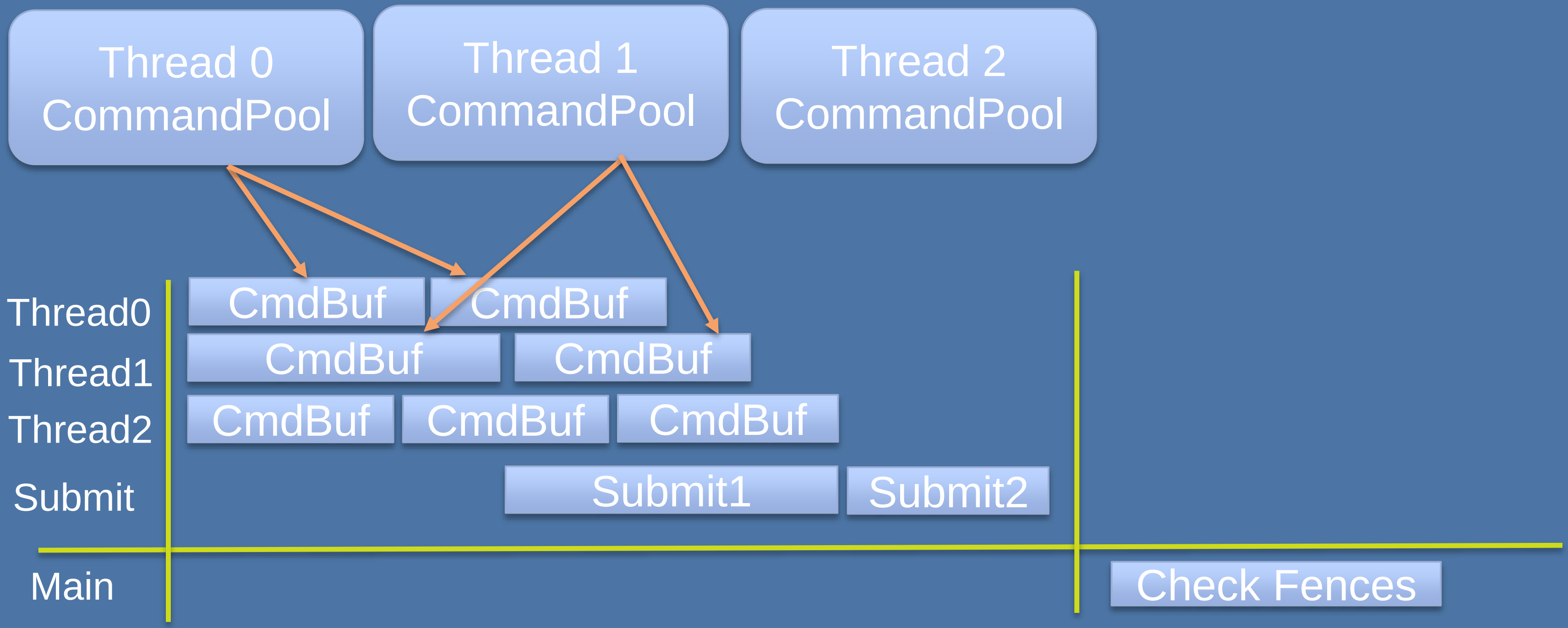

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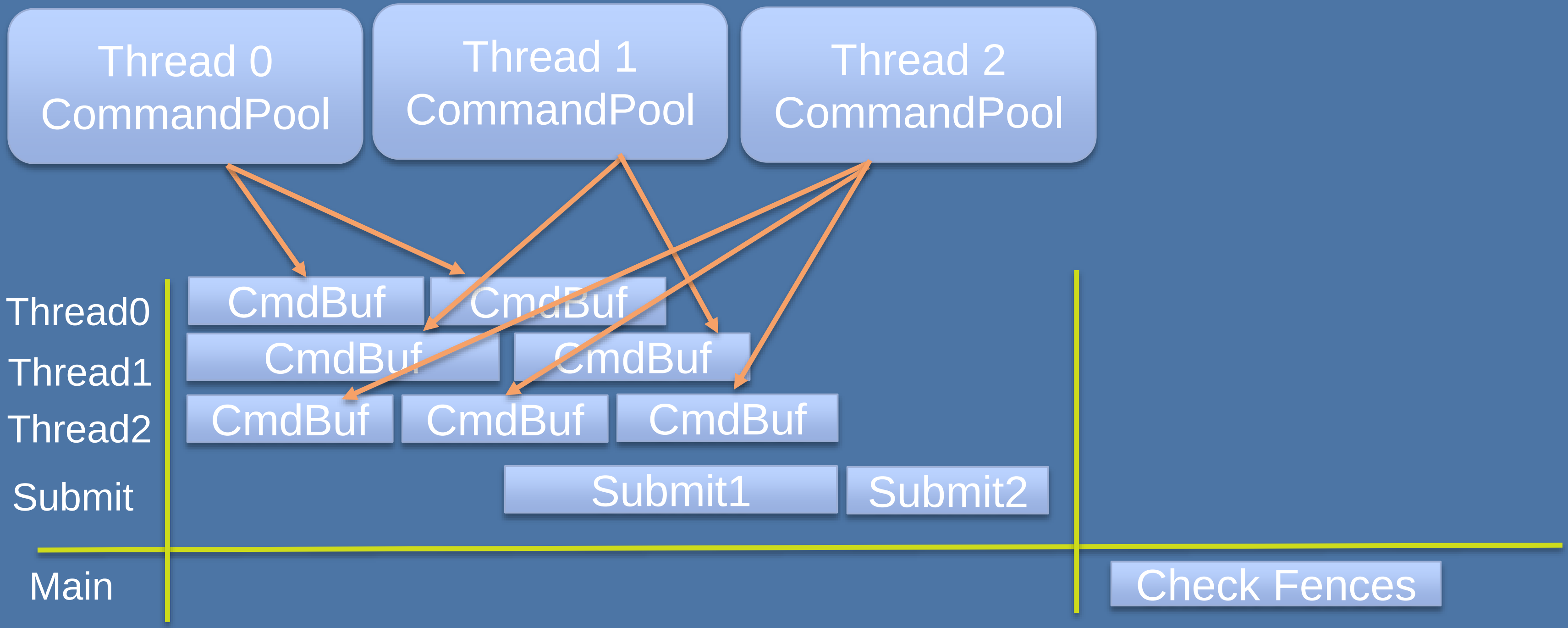

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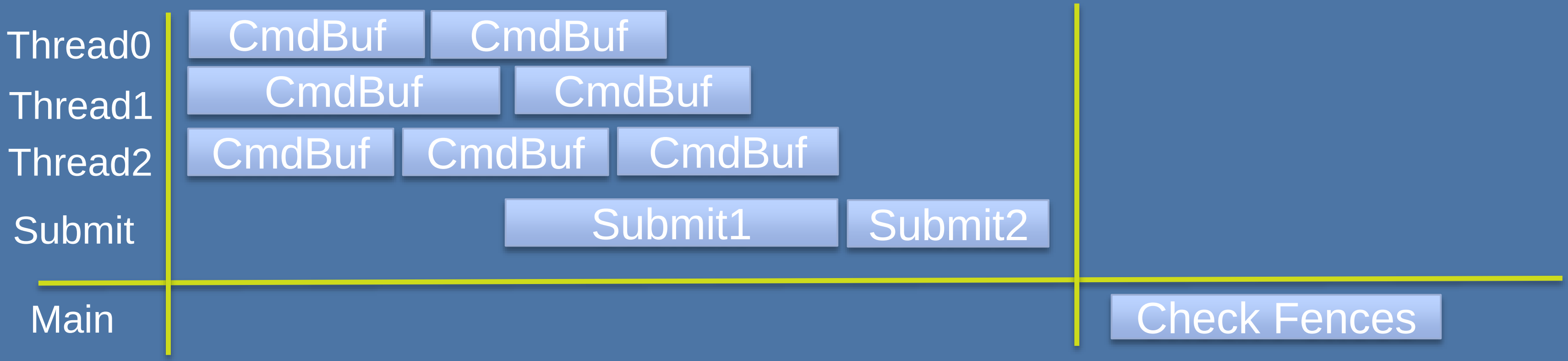

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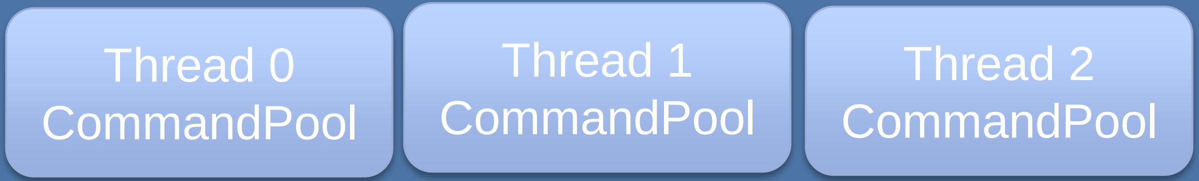

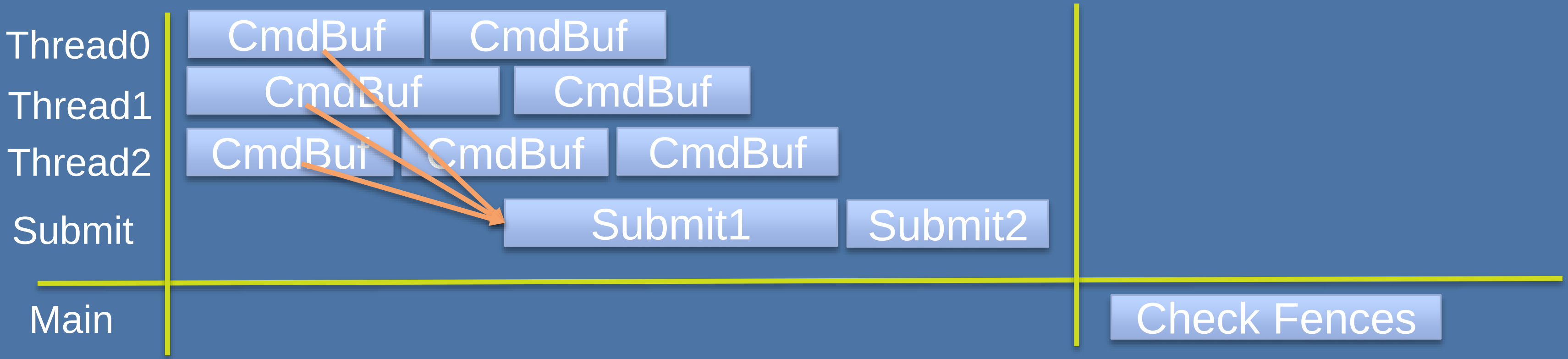

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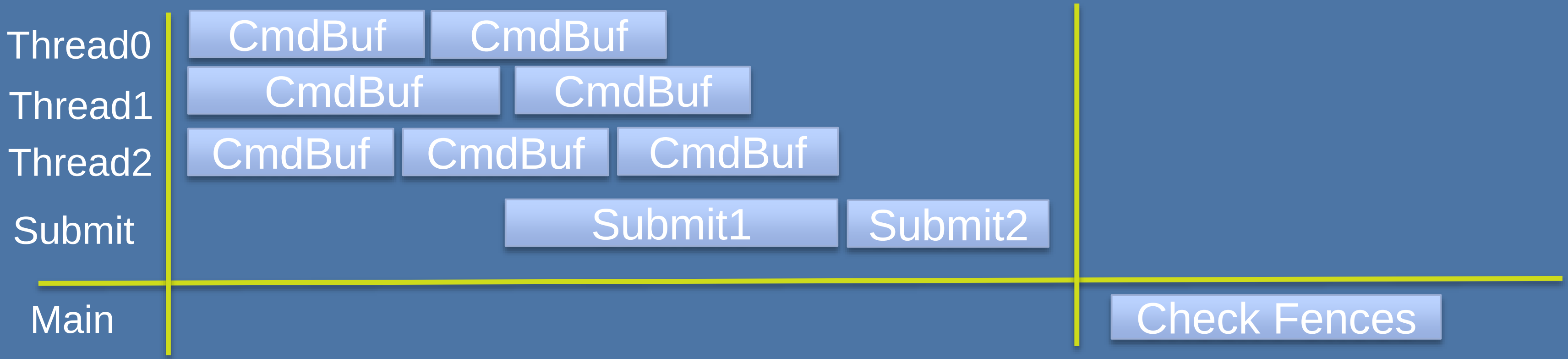

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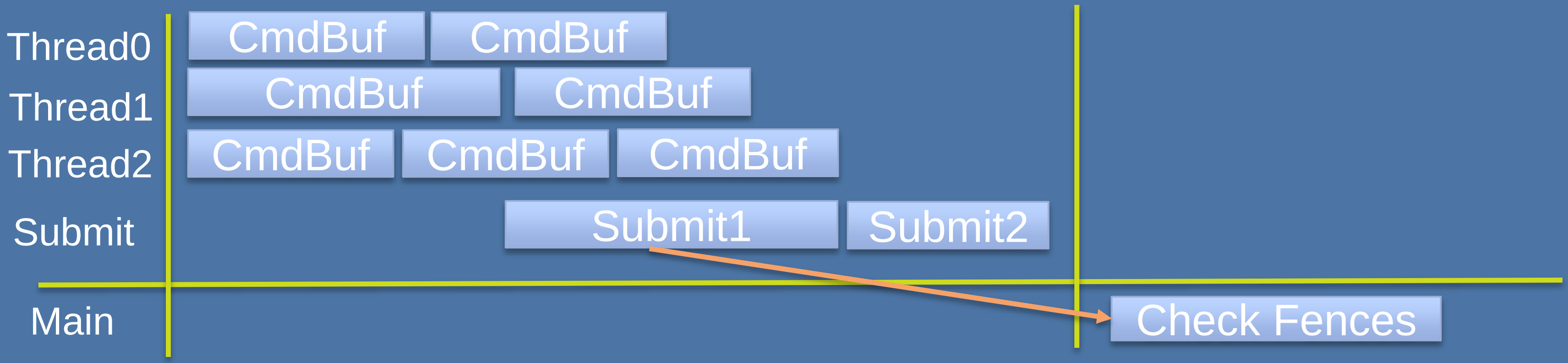

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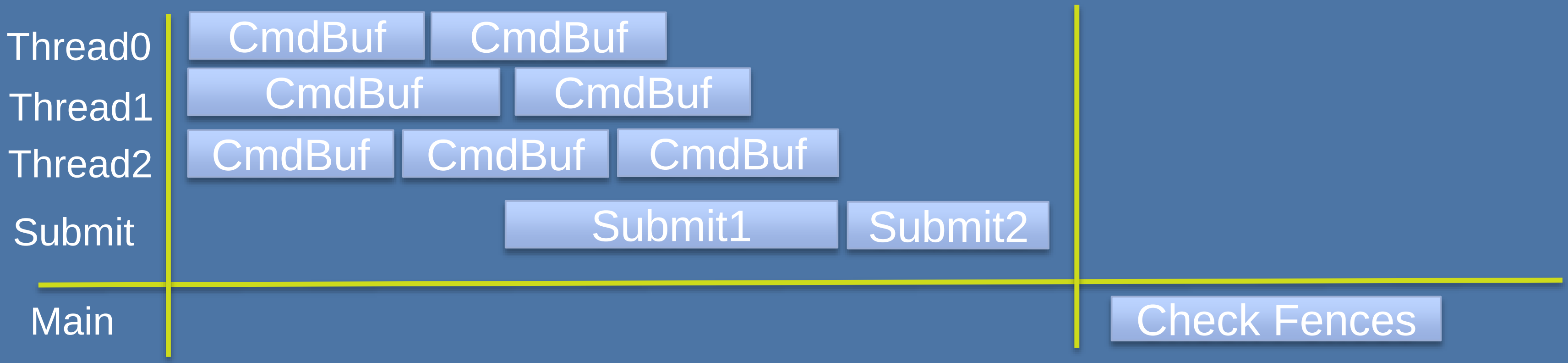

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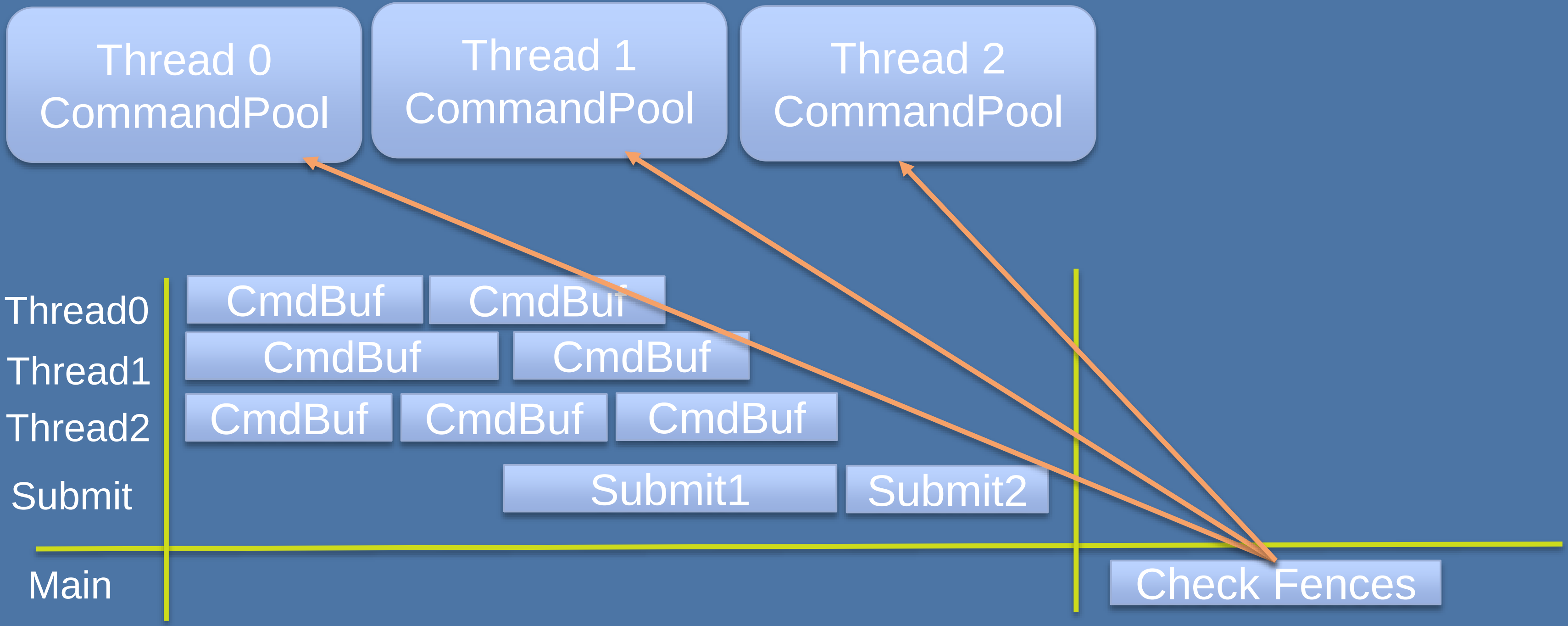

Command Buffer Performance

- Submit in batches
  - vkQueueSubmit has cost on Windows
  - Faster to group submissions together
- Minimize number of command buffers
- Minimize memory referenced per command buffer
- Use VK_CMD_BUFFER_OPTIMIZE_ONE_TIME_SUBMIT_BIT
  - Optimize for one-time submission

Memory Management

General Strategies

- Pool resources together
  - Reduces memory reference count
- Use per-thread pools to reduce contention
- Recycle dynamic pools on frame boundaries

Resources

Static Resources	Dynamic Resources
• Global Pools • Device Only • Textures/Render Targets • 128MB Pools • VB/IB/CBs • 8MB Pools	• Per-Thread Pools • Host Visible (Persistently Mapped) • VB/IB/CBs • 8MB Pools

Dynamic Vertex/Index Buffers

- To update:
  - Grab new offset from per-thread pool
  - memcpy into pool
  - Bind VBs with: vkCmdBindVertexBuffers(..,buffer,offset)
  - Bind IBs with: vkCmdBindIndexBuffer(..,buffer,offset,..)
- Recycle pools when last GPU fence of frame retires

Dynamic Uniform Buffers

- Differences from VB/IBs:
  - UBOs are bound via descriptors
  - Use dynamic UBOs to avoid vkUpdateDescriptors
  - Pass UBO offset to vkCmdBindDescriptorSets

Dynamic Textures

- Staged in persistently mapped buffers
  - Recycled per-frame
- Copy with vkCmdCopyBufferToImage

Descriptor Sets

Descriptor Set - Ideal

- Allocate and bake descriptor sets up front
- Group sets by update frequency
- Only update changed sets

Descriptor Set - Reality

- Difficult to bake descriptors with DX11-like abstraction
- Our approach
  - Pre-allocate descriptor sets with fixed slots
  - Only bind to used slots
  - Update descriptors each draw

Summary

- Source 2 Overview
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  - Descriptor Sets

Questions?

- dang@valvesoftware.com
- Khronos BOF:
  - Wed. August 12th, 5:30-7:30
  - JW Marriott LA Live in the Platinum Ballroom Salon F-I