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Zink: reducing stutters with uber shaders

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Collabora

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Hi

- Linux, Vulkan, Rust etc. tinkerer
- Zink/Mesa contributor since Jan 2023
- Some of things I've done on Zink:
  - fixed a bunch of things
  - added emulation for GL_POINT, edge flags, pv mode and other features

The problem

- OpenGL has features controlled by state
- Zink may do emulation in shaders
  - some of them don't exist in vulkan, you would use shaders instead
  - each state might require a shader variant
  - state only known at draw time
- $\Longrightarrow$ compilation stutters

Precompilation

Compile variants ahead of time?

- Explosive number of combinations
- that $*$ user shaders

Current state

- Zink precompiles base variants
  - works great when no emulation is needed
  - does nothing otherwsie

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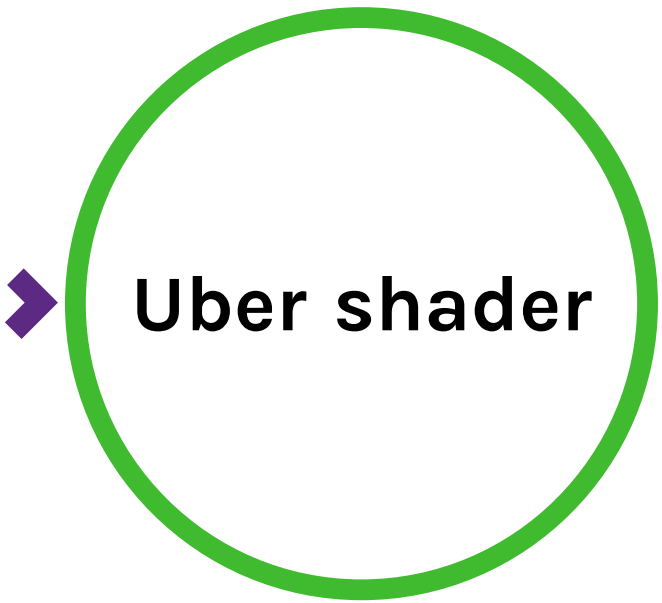
Uber shaders



- Big shader that can do all emulation
- Dynamically controlled

- Advantages:
  - no need for variants $\Longrightarrow$ can be precompiled
- Disadvantages:
  - potentially slower (bad branching and register pressure)
  - takes longer to process and compile

So ...

- Kick uber shader compilation ASAP
  - done asynchronously with util_queue
- When drawing
  - use variant when ready
  - bind uber shader if no variant is ready
  - kick variant compilation
- Best of both worlds

Presentation Outline

What does it look like in practice

Implementing in Zink

Introducing uber shaders

Current state of the patch

Some numbers

NIR passes

- We don't have the luxury of just creating shaders
- The user (gallium frontend) provides them
- Emulation done with NIR passes most of the time

Sysvals

- Sysvals are great
- NIR passes might use sysvals for parameters
  - lower to push constant loads for uber
  - lower to inlined constants for variants

Changes to passes

- Making sure sysvals are used for all parameters
- All passes need a way to be dynamically disabled
- Sometimes no changes are necessary (nir_lower_alpha_test)
- Sometimes not enough
  - nir_lower_flatshade changes variable attributes
  - can't be changed dynamically
  - every var needs to be duplicated and bcsel-ed from fragment
  - interface needs to match between multiple shader combinations

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Hilbert's shader slots

- Each variable slot becomes slot $* 2$
- Each duplicated variable goes in slot $* 2 + 1$

but..

- We don't have infinite rooms ...

Alternative solutions

- Vulkan extension to expose all attributes and barycentric?
  - VK_KHR_fragment_shader_barycentric exists
  - stable vertex order?
  - not widely available

nir_passthrough_gs

- Geometry shader used to emulate some features
- Interface needs to match with vs or tes
- Not the only emulation GS
- Created on demand
- Causes precompiled GPLs to be discarded and disabled

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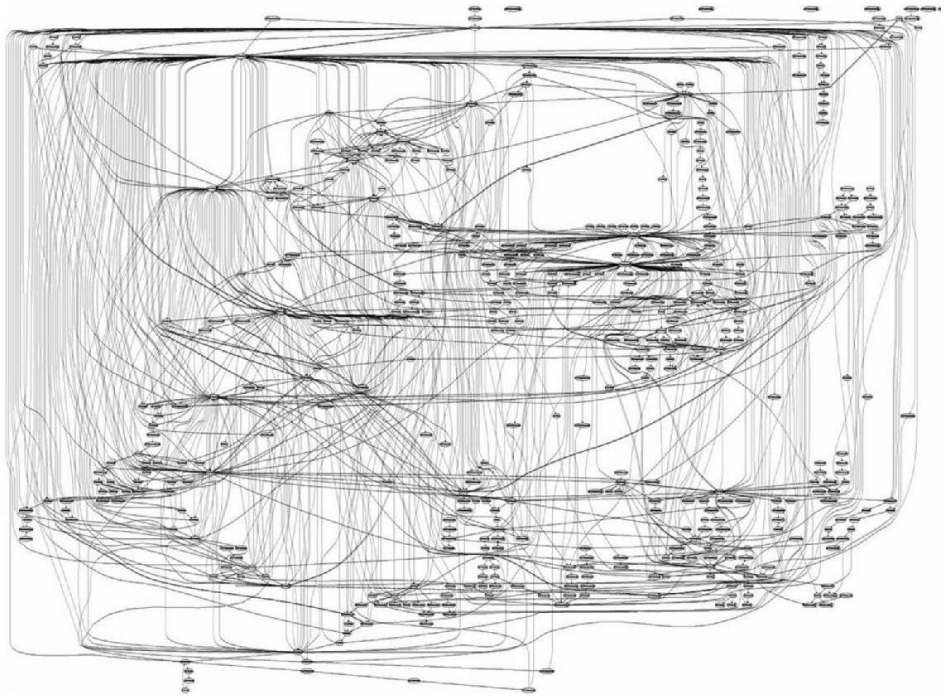
Shaders in Zink

- Shader caching in Zink is very simple, here is a diagram:



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Shaders in Zink

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Shaders in zink

- Shader state gets created and bound
- At draw time:
  - a pipeline is searched for state hash
    - if found it might get replaced with an optimized linked pipeline
  - if not found a pipeline is created from current program + some state

Shader in zink

- Programs are fetched from a cache
  - (the key is a hash of user shaders and some state)
- To handle variants the shader modules are updated
- Shader modules cached by shader keys
- Pipeline libraries for variants are stored in a cache (owned by program)
- Caches might be filled asynchronously

Asynchronous precompilation

- During shader state or program creation compilation is kicked
- Entry added to cache
- Entry contains a fence
  - on cache hit wait on fence

Cached cache

- Some games use a separate context to compile programs asynchronously
  - DOOM 2016 does this
- To support this zink will share the pipeline lib caches across contexts
  - this is effectively a cache for the cache
  - same key as program caches

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Variants handling

- When separate shaders are used zink replaces the program
  - whatever was precompiled gets lost
- we need to keep the uber shader around

Variants handling

- We now have a program per variant
  - a program only holds one GPL
  - a cross context cache is used for uber shaders GPLs
- Programs now hold a cache of variants
- Fast path for base variant
- When we need a variant:
  - if cache hit check fence
  - if the fence is signaled use variant
  - if fence not signaled or cache miss use uber
  - on cache miss we also start the kick compilation

Compiling variants

- Compiling a variant requires some steps
  - program created from separate shaders must have been replaced
  - run compilation pipeline to get the shader modules
  - create gpl
- For each stage the corresponding caches and fences are checked
- If any not ready use uber and kick job for the next stage
- If all stages are done use variant prog

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Supported legacy features

- PIPE_CAP_GL_CLAMP
- PIPE_CAP_CLIP_PLANES
- PIPE_CAP_FRAGMENT_COLOR_CLAMPED
- PIPE_CAP_ALPHA_TEST
- PIPE_CAP_FLATSHADE (wip)

Current state of the patch

- Two branches
  - dirty branch about 80 commits
  - clean branch about 60 commits
- Plan is to land what has been cleaned first
- Some features have not been tackled at all yet

Requirements

- All requirements for Zink's optimal path
  - GPL, dynamic state and others
- 256 bytes of push contants

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A pathological example

- OpenMW trace
- Uses ucp and GL_CLAMP
- At one point it sends a whole bunch of shaders
  - this will always stutter on any driver
  - variants need to be compiled for each shader

The numbers

- Without patches:
  - cold cache: 893ms
  - hot cache: 262ms
- With patches:
  - hot cache: 276ms
- ???

What is going on?

A check is performed that might disable the uber shaders path

```
bool can_use_uber = zink_can_use_uber(&ctx->gfx_pipeline_state);
```

- single feature not supported by the uber shader
  $\Longrightarrow$ stutter
- added overhead (TODO improve)

More numbers

let's hack it to always use the uber shader path

```
bool can_use_uber = true || zink_can_use_uber(&ctx->gfx_pipeline_state);
```

- Rendering breaks a bit
- Without patches:
  - no disk cache 388ms
  - with disk 262ms
- With patches:
  - no disk cache 317ms
  - with disk 221ms
- Improvement!

More recent numbers

Those are numbers after rebasing on more recent zink

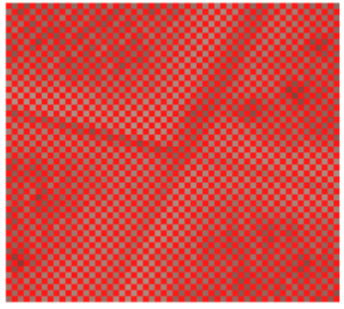
- Without patches:
  - no disk cache 504ms
  - with disk cache 383ms
- With patches:
  - no disk cache 453ms
  - with disk cache 360ms
- With patches and hack:
  - no disk cache 382ms
  - with disk cache 310ms
- improvement!

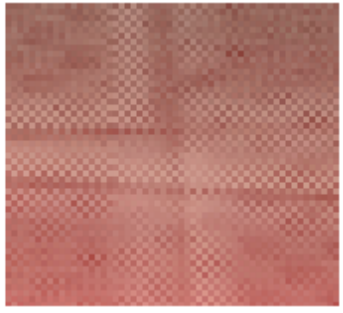
Currently working on...

- Only start compiling uber shaders once they are needed once
  - otherwise pre compile base variants
  - cuts down precompile time for well behaved applications
  - requires annoying logic

Visualizing uber shaders

- Just output red from uber fragment shaders
  - objects often covered or offscreen
- Use discard in a checkerboard pattern for non uber
  - uber still writes all pixels so always visible
  - those pixels would never get cleared so alternate pattern
  - previous frames will remain in the non drawn pixels





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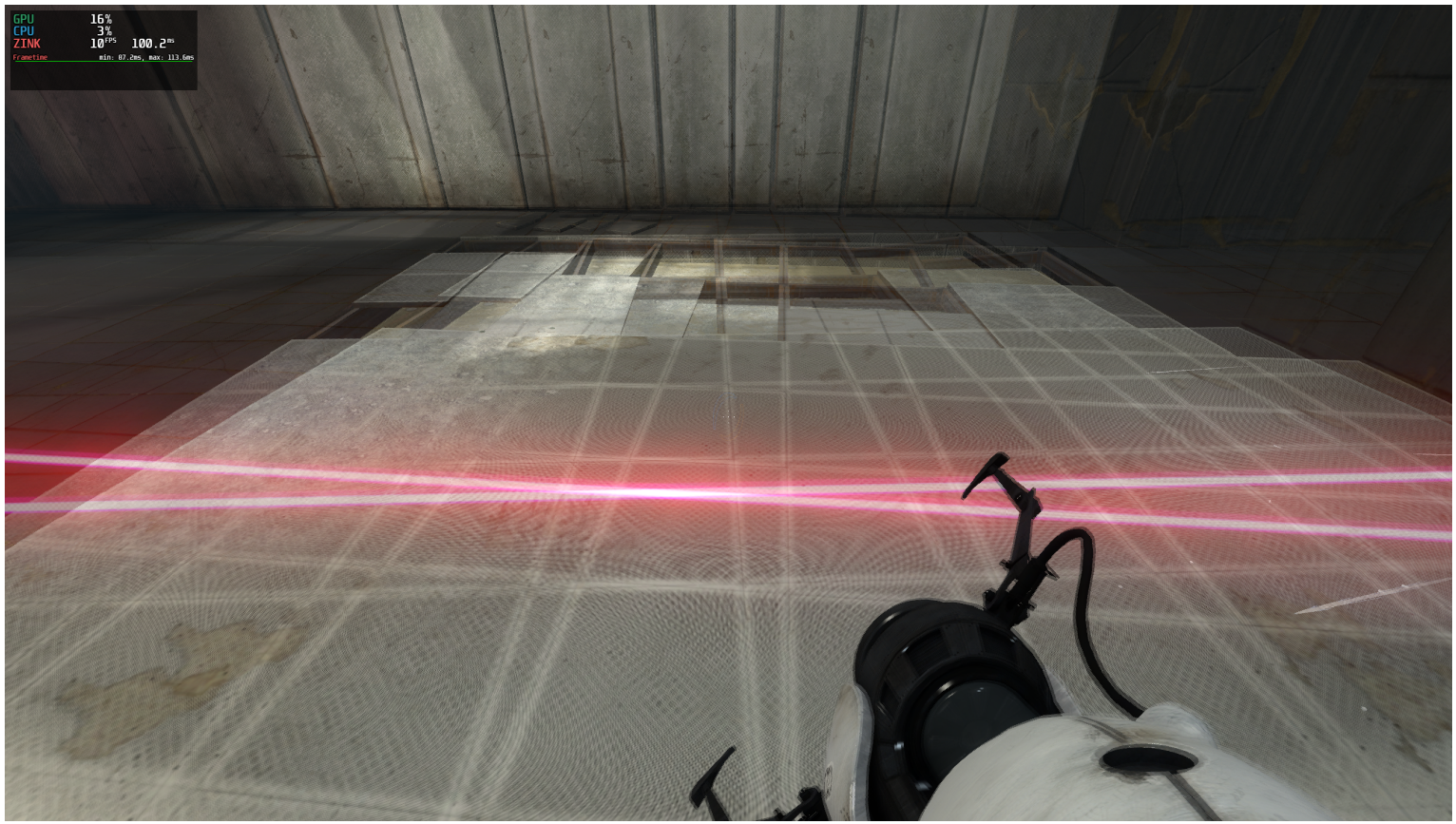

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Visualizing uber shaders

Demo!

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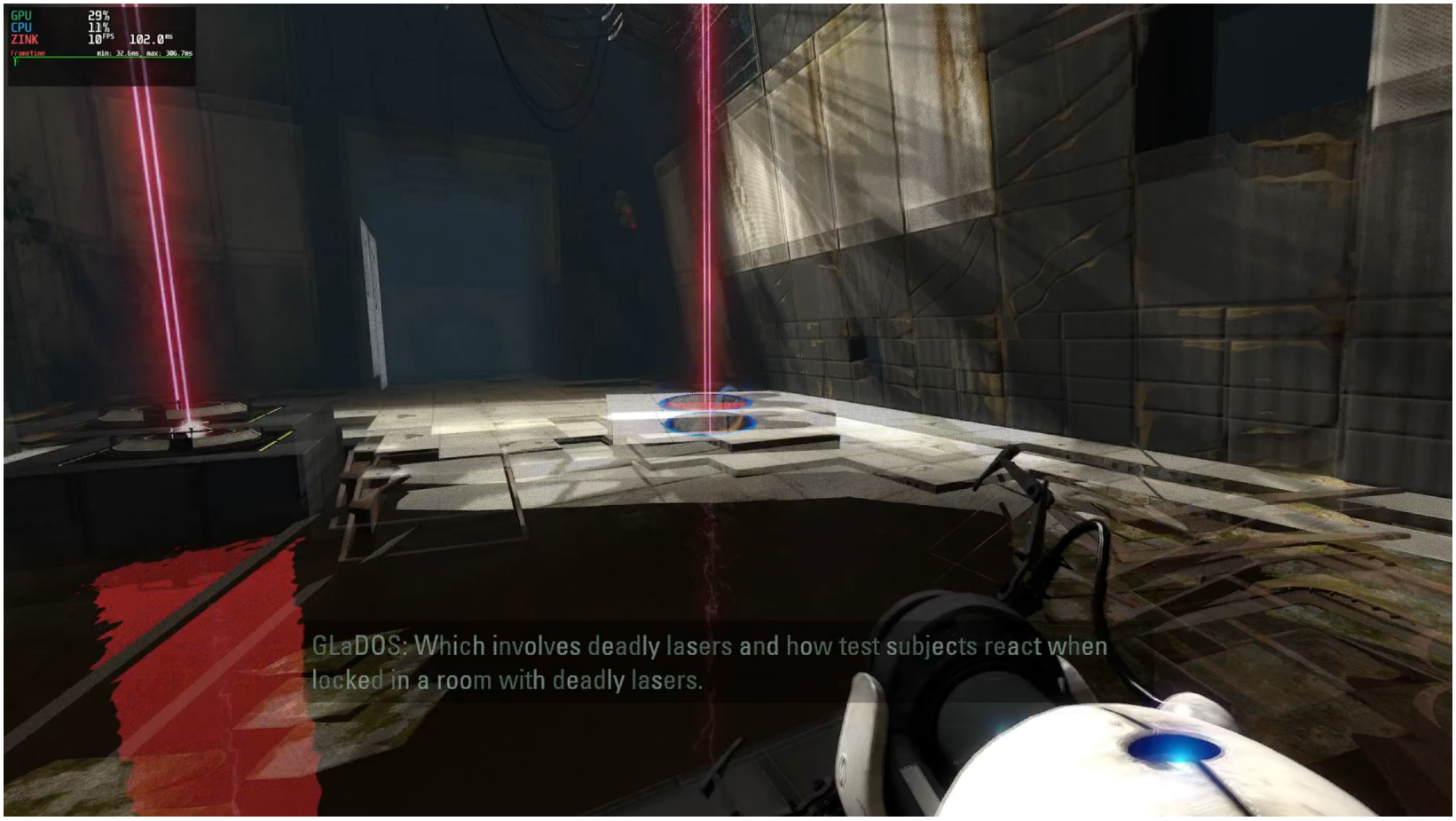

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Thanks

- Collabora
  - for allowing me to work on this
- Erik Faye-Lund @kusma
  - orignal author of Zink
  - helped me getting started with Zink
  - helped discussing spec details
- Mike Blumenkrantz @zmike
  - originally proposed I'd work on this
  - tons of suggetions
- other people that have or will help review
  - @zmike
  - @alyssa

Thanks!

Q & A

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