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
- 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 otherwise
Uber shaders

- Uber shader
- Big shader that can do all emulation
- Dynamically controlled
Advantages:
- no need for variants ➔ 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
Hilbert's shader slots

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

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:
Shaders in Zink
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
Presentation Outline

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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
Presentation Outline

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Some numbers

Open First
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 contents
Presentation Outline

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Some numbers
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 ➔ stutter
- added overhead (TODO improve)
More numbers

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

```cpp
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
Visualizing uber shaders
Visualizing uber shaders

Demo!
GLaDOS: Sorry about the mess. I've really let the place go since you killed me. By the way, thanks for that.
GLaDOS: Oh good, that's back online. I'll start getting everything else working while you perform this first simple test.
Visualizing uber shaders
Visualizing uber shaders

GLaDOS: Which involves deadly lasers and how test subjects react when locked in a room with deadly lasers.
Thanks

- Collabora
  - for allowing me to work on this
- Erik Faye-Lund @kusma
  - original author of Zink
  - helped me getting started with Zink
  - helped discussing spec details
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Thanks!

Q & A