Improvements to the Raspberry Pi GPU driver stack

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Who are we?

- We are open-source developers at Igalia working at the Graphics Team.
- We focus on enhancing the Raspberry Pi graphics stack, mainly on the Mesa user-space driver.
- We are representing the work done not only by us, but from other members of the Graphics Team working improving also the Raspberry Pi driver.

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Contents

- New Features (Ella)
- Performance Improvements (Juan)
- Q&A

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New extensions exposed (since 24.2 branchpoint)

- GL_EXT_conservative_depth
- GL_EXT_disjoint_timer_query
- GL_EXT_multi_draw_indirect
- GL_EXT_sRGB
- **GL_EXT_shader_framebuffer_fetch**
- GL_EXT_shader_framebuffer_fetch_non_coherent
- GL_KHR_blend_equation_advanced
- GL_KHR_blend_equation_advanced_coherent
- **GL_{ARB,EXT}_blend_func_extended**
- GL_{ARB,EXT}_timer_query
- GL_{ARB,KHR}_robust_buffer_access_behavior

Framebuffer Fetch

- We implemented this by lowering `load_output` to a V3D specific TLB read intrinsic.
- Gallium provides GL_KHR_blend_equation_advanced for us.

Dual Source Blend

- The hardware does not support dual source blend factors.
- We used the common `nir_lower_blend` pass as a software fallback.

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16 Bit Normalisation

- 16 bit normalised formats are required by OpenGL 3.2 but not supported by the hardware.
- We added a NIR lowering pass to convert to and from integer formats.
- We use the same software fallback for blending.

NIR printf

- Very helpful debugging feature.
- We added a new helper to reduce noise.

```
nir_printf_fmt_at_px(b, size, x, y, fmt, ...)
```


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Robustness

- Added so CTS can detect resets.
- We added reset counters to the kernel driver to support this.

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OpenGL 3.2 - Pending issues

- The driver is missing support for non seamless cubemaps:
  - The hardware only supports seamless cubemaps.
  - Zink has a lowering pass but some piglit tests fail.

Performance improvements

- For last year, we focused on performance improvements on GPU limited scenarios using Full-HD target resolution.
- We have analyzed the performance of V3D using several GLES gfxbench traces, and we have achieved an average of ~**32.29%** FPS improvement in these scenarios since the last XDC, with cases from ~**4.92%** to ~**68.32%** FPS improvement.
- All these performance optimizations are available in stable Mesa 25.2.3

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Avoid load/stores on invalidated framebuffers

- With the information of the invalidated framebuffers we can avoid the stores of the results of tile buffer rendering and the next load if they re-used in following jobs as any read value would be undefined.
- This gets us an **+1.11%** FPS average improvement (between ~0.05% and 3.26%).

c1: "v3d: avoid load/store of tile buffer on invalidated framebuffer"

Take advantage of Early-Z optimization

- Early-Z optimization was disabled when there is a discard instruction in the draw call shader. But we can enable it at draw time if depth updates are disabled and there are no occlusion queries active.
- This gets us an **+13,21%** FPS average improvement (between 4.78% and 17.69%).

c2: "v3d: Enable Early-Z with discards when depth updates are disabled"

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Avoid loads/stores with disabled rasterization

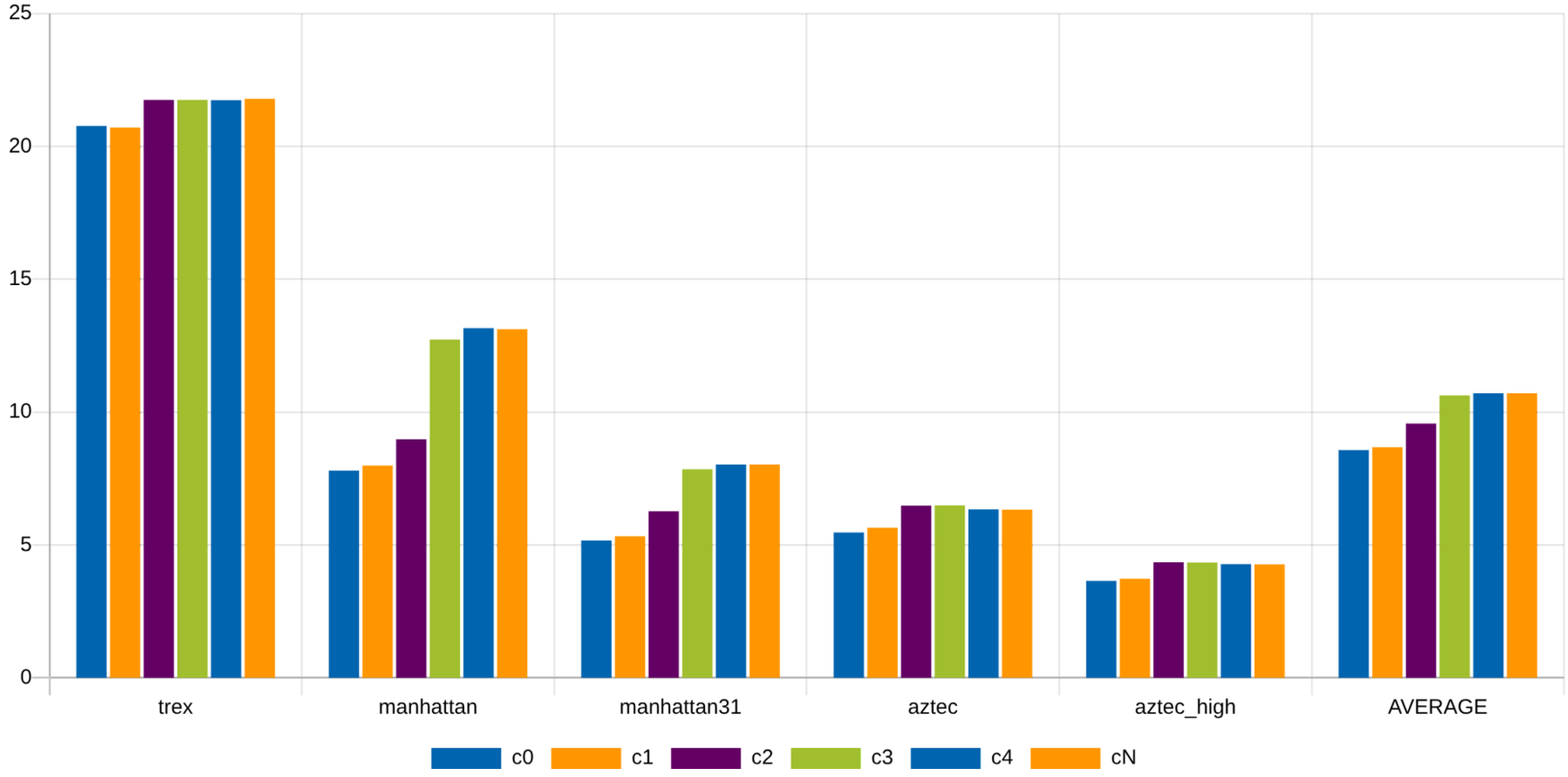
- If all draw calls submitted have the rasterizer discard enabled, we can avoid any tile buffer load/stores.
- This is specially helpful in scenarios where transform feedback is used, because the application is only interested in the geometry results.
- This gets us an **+13.32%** FPS average improvement (between 0% and 41.32%)

c3: "v3d: Don't load/store if rasterizer discard is enabled"

Avoid supertile coordination submission without rasterization

- This is another improvement when rasterizer discard is enabled.
- Even avoiding tile buffer load/stores, GPU still executes the FS in all tiles belonging to a supertile.
- This basically emits no supertile to avoid that.
- This gets us an **+1.16%** FPS average improvement (between 0% and 3.77%).

FPS over time per benchmark



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Q&A

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