Update on Open Source Vulkan Driver for Adreno GPUs

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2024-02-04
New Hardware Support

- A7XX GPUs are now supported
  - A730/A740 merged last year
  - A750 has MR on review
  - Direct (non-tile-based) rendering passes CTS tests
  - Tile-based rendering is still WIP
- Most A6XX GPU variants are supported
  - A6XX is divided in 5 sub-generations
Notable Changes

• Major Extensions:
  ○ VK_EXT_descriptor_buffer
  ○ VK_EXT_extended_dynamic_state3
  ○ VK_EXT_graphics_pipeline_library
  ○ VK_EXT_fragment_density_map
  ○ VK_EXT_inline_uniform_block
  ○ VK_KHR_dynamic_rendering

• Vulkan 1.3 is supported for a while now
Notable Changes

- A lot of recent focus was on correctness:
  - Fixing vkcts tests
  - Fixing issues in various games
- Lots of pipelines code improvements from Connor
- IR3 optimizations
- Better debug tooling
Better Debug Tooling

• Especially important for reverse-engineering
• Gave in-depth talk at 2023 XDC
  ○ "Debugging GPU faults: QoL tools for your driver"
    https://www.youtube.com/watch?v=Fl0nfK4O8r
  ○ Q

• Tooling:
  ○ GPU breadcrumbs
  ○ GPU command stream replaying
  ○ GPU command stream editing
  ○ Printing from shader assembly
  ○ Stale reg debugging
GPU breadcrumbs

- API level breadcrumbs like Graphics Flight Recorder are cool
- They may be too coarse
- They generally don't work with unrecoverable hangs
GPU command stream replaying

- Reproducing hangs and other failures may be hard
- Recording submitted commands is simple and effective
- Not all issues are reproducible this way
- Requires recording ALL used buffers

```
> ~/bin/replay /tmp/tu_vkcube.vkcube_device0_combined
Reading /tmp/tu_vkcube.vkcube_device0_combined.rd..
chip_id: 0x7090000
cmdstream 0: 169 dwords
cmdstream 1: 238 dwords
```
GPU command stream editing

- Reproducing issue is not enough
- How to find out the cause?
- What if we could edit any submitted GPU packet?
- Good news! It's easy to implement and already used in Turnip!

```c
/* pkt 4: GRAS_2D_RESOLVE_CNTL_2 = { X = 63 | Y = 63 } */
pkt(cs, 4128831);
/* pkt 4: RB_BLIT_SCISSOR_TL = { X = 0 | Y = 0 } */
pkt4(cs, 0x88d1, (2), 0);
/* pkt 4: RB_BLIT_SCISSOR_BR = { X = 63 | Y = 63 } */
pkt(cs, 4128831);
pkt7(cs, CP_MEM_WRITE, 20);
/* { ADDR_LO = 0x1f7580 } */
pkt(cs, 2061696);
```
Printing from shader assembly

- There is a fault in shader, a hang, misrenderings?
- Even the most basic print is useful!

```
    sel.b32 r0.y, c1.x, r0.x, c0.x
    sel.b32 r0.z, c1.y, r0.x, c0.y
    sel.b32 r1.y, c1.z, r0.x, c0.z
    sel.b32 r1.z, c1.w, r0.x, c0.w

    print r2.x, r0.y, r0.z, r1.y, r1.z
```

- Uses \texttt{r2.xyz} as tmp storage, prints the rest
Stale reg debugging

- Using value from stale reg is not a rare occurrence
- Could result in geometry flickering, hangs, random cts failures
- What if we write invalid values to regs:
  - All regs at the start of each command buffer
  - To regs used in renderpasses before each reanderpass/blit
Turnip and emulators on Android

- Proprietary drivers on Android are rarely updated
- Many users are stuck with old drivers and issues
- For emulators supporting all quirks of old drivers is hard
- It's easier to use Turnip in many cases
Turnip vs Proprietary Driver on Zelda

- Sony Xperia 5 II (Adreno 650) + Turnip
- Credits to @crumpetdialogue discord user on Yuzu channel
Turnip vs Proprietary Driver on Zelda

- Same device, same user, proprietary driver
Turnip runs desktop games

- Turnip implements all extension for DXVK and VKD3D-Proton
  - Adreno GPUs are rather capable ones!
- FEX emulator allows to run x86-64 apps on aarch64
- We test game traces and games themselves
Future

- Support tiling (GMEM) rendering on A7XX
  - Mark Collins is working on it
- Squeeze more performance!
- Distant future:
  - Support raytracing
  - Maybe mesh shaders are doable
Future

• Easy way to run desktop games on Android!
  ○ (NOT Igalia's project)
  ○ There is work-in-progress project called Cassia
  ○ It's a Wine+DXVK+VKD3D-Proton+FEXCore on Android
  ○ Turnip would have first party support there
But I already saw desktop games there

- Yes, people already running them! On Android, with Turnip
- Via Mobox project: termux + box64 + wine + dxvk + mesa
- Credits to Mad CatZ youtube channel:
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