

# Resolving game bugs\* using retry faults

\* and driver bugs

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**VALVE**

Linux Open-Source  
Graphics Drivers Group



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What's a page fault?

# VA mapping

Userspace can ask the kernel to map buffers at arbitrary addresses in their virtual address space.

## VA mapping on amdgpu

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The kernel submits a job to the SDMA to update page tables with the requested mapping.

# What's a GPU page fault?

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GPU page fault:

When the application submits a GPU job that tries to access an address where nothing is mapped.

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## **Note about sparse**

Sparse mappings don't really count as a page fault.



How do we handle page faults?

# Page faults on AMD GFX8 and older

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- Memory controller walks the page table, doesn't find a valid, mapped page
- Sends an interrupt to the CPU
- Reads data from a pre-configured dummy page (typically zeroes)
- Application reads zeroes

## Page faults on AMD GFX9 and newer

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- Memory controller walks the page table, doesn't find a valid, mapped page
- Sends an interrupt to the CPU
- GFX block cannot continue and hangs
- Kernel tries to recover the GPU
- Application observes a GPU reset (and likely crashes)



Why care?

# Why care about page faults?

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Users don't want their GPU to hang.

- Page faults are a "popular" class of bug

# Why care about page faults?

Users don't want their GPU to hang.

- Page faults are a "popular" class of bug
- Could be game bugs
- Could be driver bugs in userspace
- Could even be driver bugs in the kernel



What's a retry fault?

# Intended use case for retry faults

Datacenter workloads that don't (or can't) have all data resident.

- Application just accesses memory that isn't yet mapped in its VA space
- When a page fault happens, move the "missing" data to VRAM and map it in the VA space
- Application can continue uninterrupted (no hang, no reset)

# Intended use case for retry faults

Mainly used on datacenter GPUs (MI series).

- Just an afterthought on consumer products
- Not utilized for graphics
- Missing HW configuration, kernel bugs



How do we use that?

## Our use case for retry faults (for graphics)

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Game accesses an unmapped VA (virtual address) due to a bug.

## Our use case for retry faults (for graphics)

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Game accesses an unmapped VA (virtual address) due to a bug. \*

# Our use case for retry faults (for graphics)

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Game accesses an unmapped VA (virtual address) due to a bug. \*

- Game bug
- Userspace driver bug
- Kernel driver bug

# Our use case for retry faults (for graphics)

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What can we do?

- On fault, map "dummy page" to the unmapped VA
- Application reads zeroes, can continue uninterrupted

# Our use case for retry faults (for graphics)

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What can we do?

- On fault, map "dummy page" to the unmapped VA
- Application reads zeroes, can continue uninterrupted
- ... or can be gracefully terminated without triggering a GPU reset

# Our use case for retry faults (for graphics)

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The challenge:

- Test the feature on consumer GPUs
- Add missing register programming
- Filter the interrupts that the HW spams

# Our use case for retry faults (for graphics)

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Current status:

- Mostly works on RDNA3 and RDNA4 dGPUs
- Needs a little work to be enabled by default

## Our use case for retry faults (for graphics)

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Are all page fault issues fixed with this?

## Our use case for retry faults (for graphics)

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Are all page fault issues fixed with this? No!

- Page faults are still bugs that need to be investigated and fixed
- However, at least they won't hang your GPU anymore...



# Future plans

# What's next?

## TODO:

- Fix a race condition
- Enable by default on RDNA3-4 dGPUs
- Filter interrupts on APUs and RDNA1-2

# What's next?

Long-term plan:

Implement `VK_KHR_device_fault`

Give more control to userspace.

# Thanks

## Questions, suggestions, discussion?

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