Graphics Performance Analysis with FrameRetrace: A Responsive UI for Apitrace

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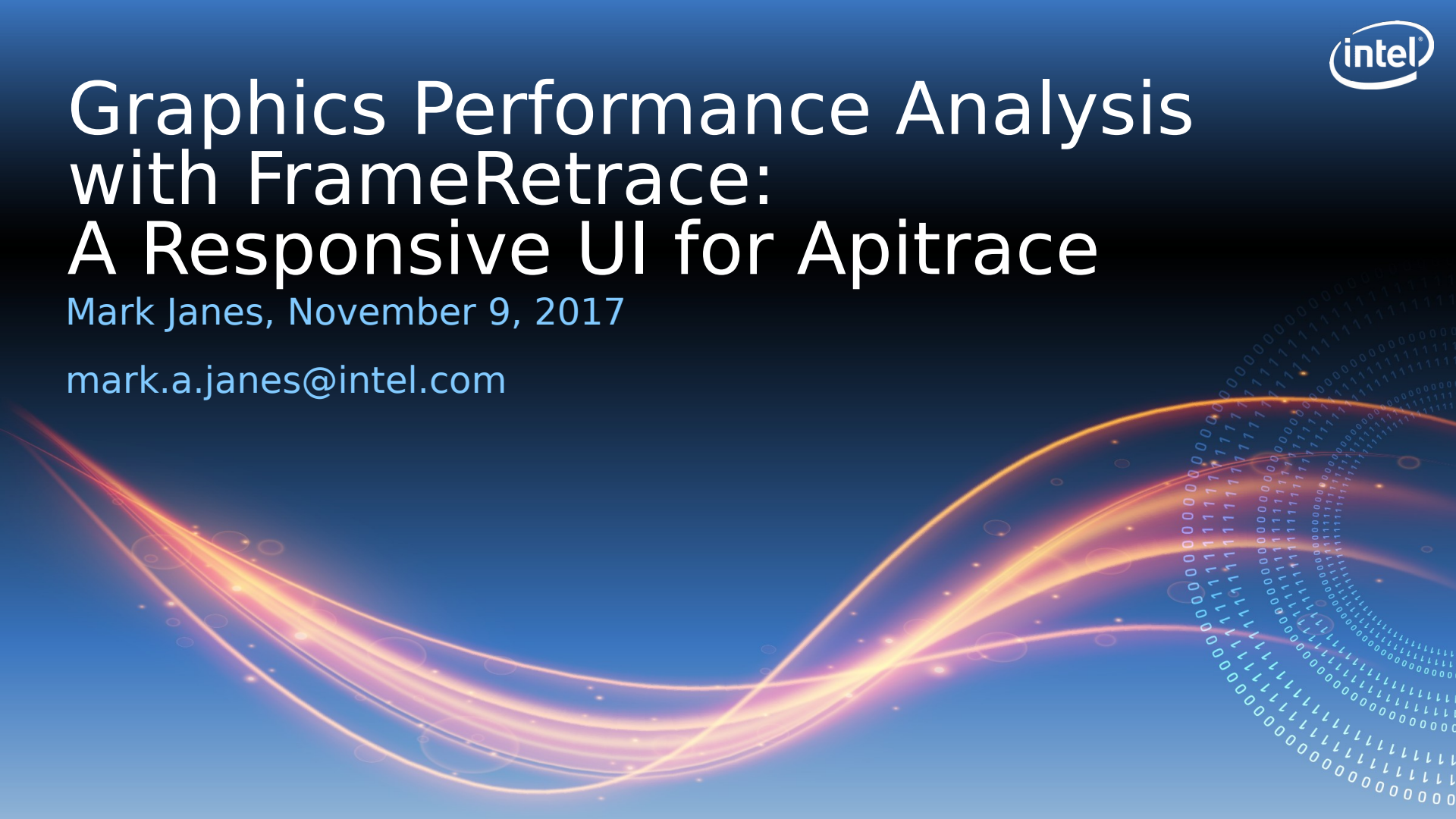

About me:

- Working on Linux platforms since 2004, with a background on embedded devices.
- Contributed to Intel’s Graphics Performance Analyzers tools for Android OpenGLES applications 2011-2014.
- Joined Mesa in 2014, working on performance tools and automation.

GPU Performance Analysis Workflow

- Investigate system bottlenecks first
  - top, gputop, rapl
  - 100% GPU utilization with lower CPU utilization indicates a GPU-bound workload
  - TDP limited workloads cause GPU clock rate to fall.
  - MESA_DEBUG=perf

GPU Performance Analysis Workflow

- CPU Bound workloads have traditional tools
  - perf, callgrind, cachegrind, sysprof
- GPU performance analysis has a sparse landscape of Linux tools
  - AMD GPU PerfStudio, Nvidia Linux Graphics Debugger, QApiTrace
  - Leverage GPU hardware counters to quantify the cost of asynchronous GPU operations.
  - Live experimentation to see the effect on performance.
  - Deeply investigate a graphics workload.

GPU Tools stumbling blocks

- Generally hardware-specific
- Mostly closed source
- Linux support is an afterthought
- Tracing/retracing not reliable
- Low numbers of users
- Mesa support for GPU performance counters

FrameRetrace: frame analysis based on ApiTrace

- Widely used and high quality trace/retrace
- https://github.com/janesma/apitrace
- Cross-platform: Linux and Windows
- Hardware agnostic: Support for Intel, AMD. More to come.
- Upstream GPU Counter support in Mesa and Kernel for Haswell and later.
- Leveraged by Intel Mesa team to identify and fix several performance issues in i965.

FrameRetrace: frame analysis based on ApiTrace

- GPU Metrics for each render
- Render target visualization and experiments
- Api log
- Batch disassembly
- Shader analysis, live editing, and assembly
- Uniform constant display and live editing
- Render experiments
- State display and live editing

Demo


frameretrace
Metrics Filter:
Refresh
2506529
2005223
1503917
1002612
501306
Vertical Metric: GPU Core Clocks
Horizontal Metric: No metric
Shaders
RenderTarget
Api Calls
Batch
Metrics
Experiments
Uniforms
State
Clear before render
Stop at render
Highlight selected render

Other features

- Windows support provides important leverage for open source driver teams seeking to find Mesa performance gaps.
- Proposed features:
  - Display texture state, with mip clamp experiment
  - Display geometry mesh
  - Depth buffer visualization
  - Overdraw / hotspot rendertarget visualization
  - UI improvements
  - Support for more hardware
  - Android support

Caveats

- Currently a one-person project, with help
  - Thanks to Laura Ekstrand, Robert Bragg, Lionel Landerwelin, Eero Taminen, Pekka Jylhä-Ollila
- Experiments require intricate state tracking
- Some workloads do not have single-frame run loops

AMD_performance_monitor support

- FrameRetrace has been enhanced to support Intel's on-die AMD GPUs
  - GPUTime, GPUBusy, TessellatorBusy, HSBusy, DSBusy, GSBusy, PSBusy, CSBusy, VSVerticesIn, HSPatches, HSVALUInstCount, HSSALUInstCount, HSVALUBusy, HSSALUBusy, DSVerticesIn, GSPrimsIn, GSVerticesOut, GSVALUInstCount, GSSALUInstCount, GSVALUBusy, GSSALUBusy, PrimitivesIn, ClippedPrims, PAStalledOnRasterizer, PSPixelsOut, PSExportStalls, PSVALUInstCount, PSSALUInstCount, PSVALUBusy, PSSALUBusy, CSThreadGroups, CSWavefronts, CSThreads, CSVALUInsts, CSVALUUtilization, CSSALUInsts, CSVFetchInsts, CSSFetchInsts, CSVWriteInsts, CSFlatVMemInsts, CSVALUBusy, CSSALUBusy, CSMemUnitBusy, CSMemUnitStalled, CSFetchSize, CSWriteSize, CSCacheHit, CSWriteUnitStalled, CSGDSInsts, CSLDSInsts, CSFlatLDSInsts, CSALUStalledByLDS, CSLDSBankConflict, TexUnitBusy, TexTriFilteringPct, TexVolFilteringPct, DepthStencilTestBusy, HiZTilesAccepted, PreZTilesDetailCulled, HiZQuadsCulled, PostZQuads, PreZSamplesPassing, PreZSamplesFailingS, PreZSamplesFailingZ, PostZSamplesPassing, PostZSamplesFailingS, PostZSamplesFailingZ, ZUnitStalled, CBMemRead, CBMemWritten, CBSlowPixelPct
- AMD does not meaningfully implement their own metrics extension, and requires the GPA library to produce data.
- Raspberry Pi and Nouveau supports AMD's extension

GPUTop demo

- New UI built on top of ImGui
  - Simplifies build and deployment
  - System-wide & per-context metrics graphs
  - Text collection of GPU metrics
  - (in progress) timeline of trace events

Questions?


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