Vulkanised 2023

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Using ANGLE as a System Graphics Driver

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Agenda

1. ANGLE
2. ANGLE instead of native GLES
3. The Productization Journey
4. VK Extensions and GLES 3.2
5. The Performance Story
6. Replacing GLSLANG
7. Future Work

Acknowledgements

- Google ANGLE and Android Teams
- Samsung ANGLE Team (US, UK, India, Korea)

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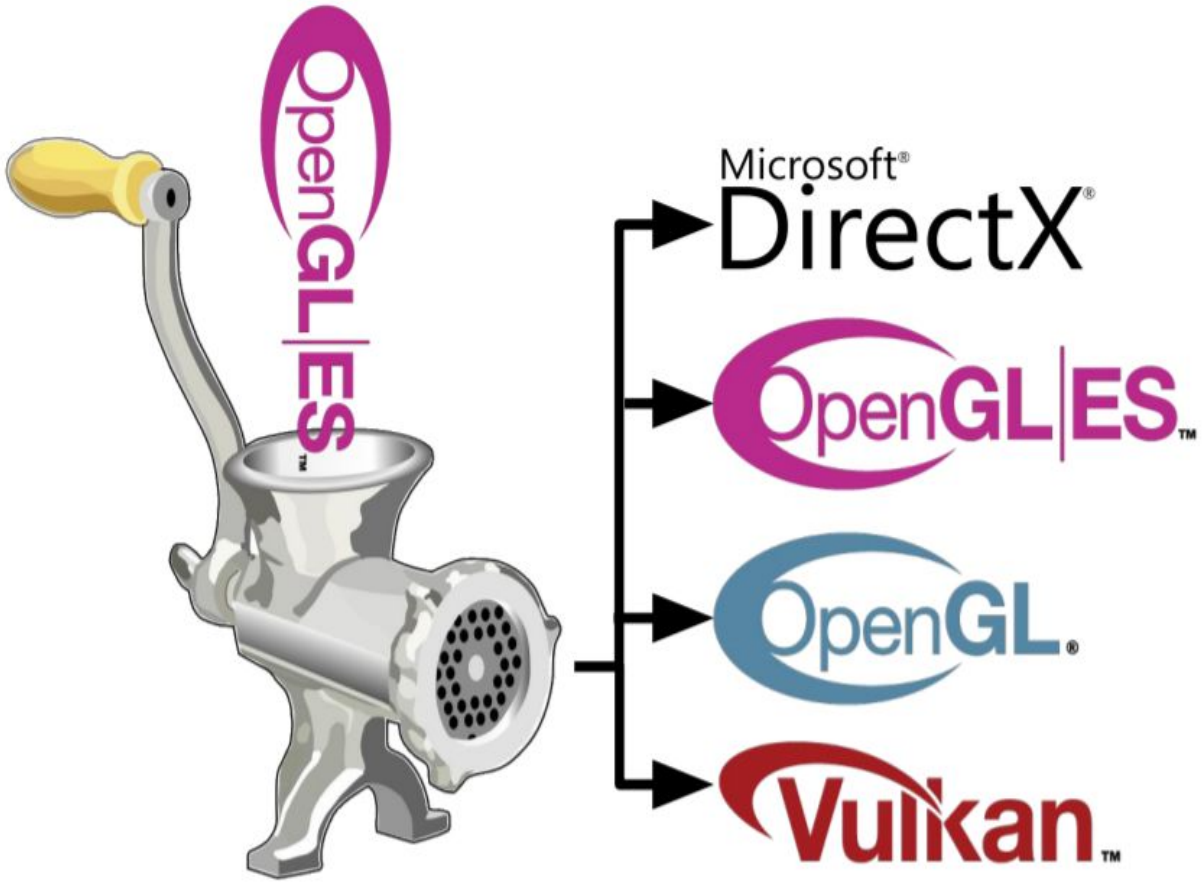
What is ANGLE?

Almost Native Graphics Layer Engine

Mobile graphics engine which translates OpenGL ES to multiple output APIs



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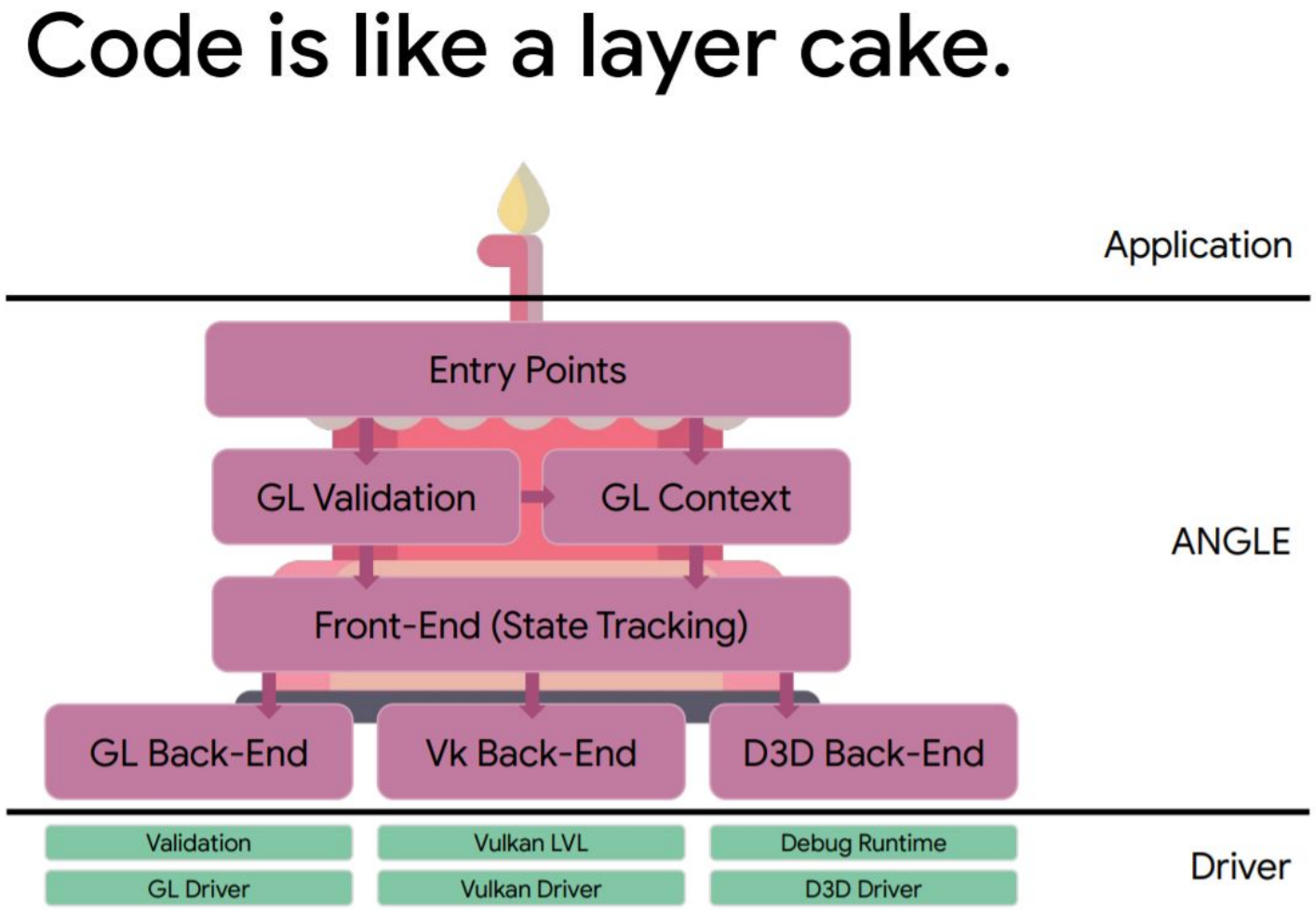
What is ANGLE?



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ANGLE instead of a Native OpenGL ES Driver

Benefits of using ANGLE

Reduces GLES "Total Cost of Ownership"

Allows IHVs to focus all gfx efforts on Vulkan

- HW and FW updates serve GLES and VK API simultaneously
- Most new features are going to be available in VK only

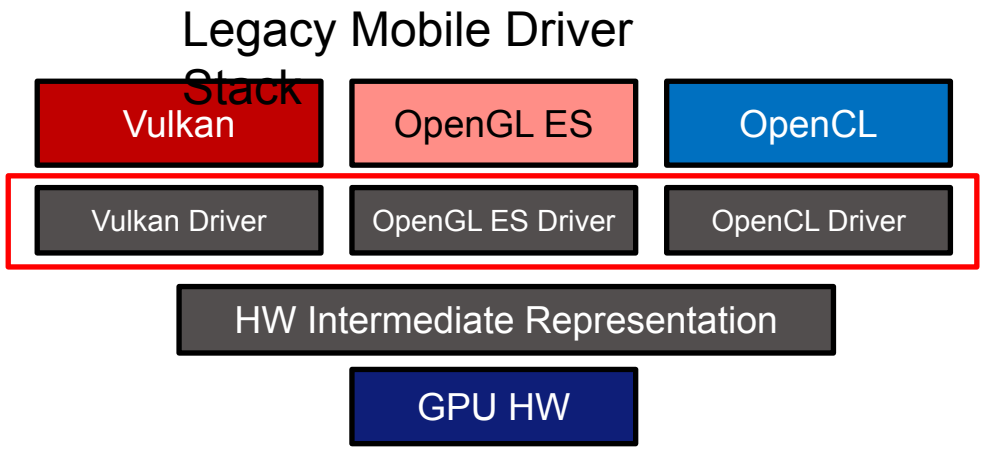
Vulkan can improve some GLES intrinsically.

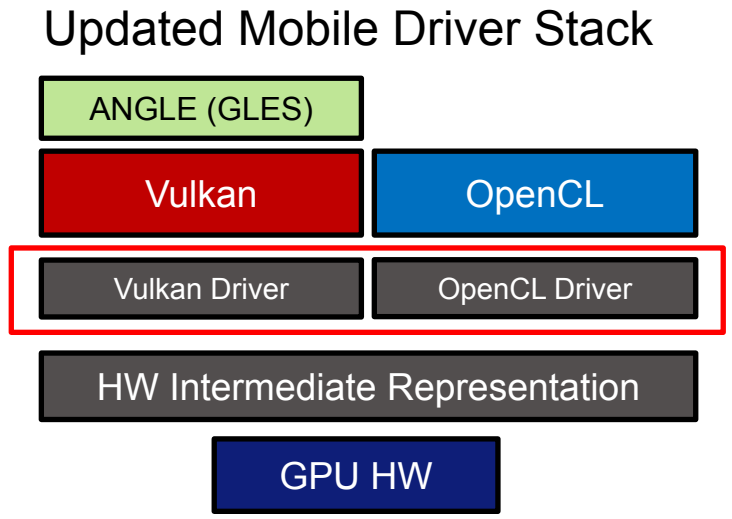
- Mipmap generation improvements
- Finer grained barriers
- Pipeline caching

Conformance debugging of GLES is simplified

- Run ANGLE on multiple drivers (Vendor Driver / Swiftshader) for process of elimination

Better Security: not having an GLES native driver reduces the attack surface for the platform.





ANGLE instead of a Native OpenGL ES Driver

Costs of Using ANGLE

Not all GLES features can be directly translated to Vulkan and require emulation.

- Private extensions are required until Vulkan APIs can be developed and approved.
- Example: YUV extensions for render target are not available yet in Vulkan API

Performance overhead can reduce application framerate.

- This overhead can be absorbed from hardware year-over-year improvement (YOY)
- See the following slide.

Pipeline creation introduces additional delays and startup costs

- Vulkan APIs restricts pipeline creation until drawcall.
- Therefore pipeline caches need to be warmed up in both ANGLE and VK layers.

The Productization Journey

DEQP Pass Rate

Where we started from Circa 2019

- deqp 2.0 pass rate ~91%
- deqp 3.0 pass rate ~16%
- deqp 3.1 pass rate ~5%
- EGL pass rate ~16%

Initial Perf Median at 50% native

Android N (2018 Device)

- Trex onscreen
  - Native GLES – ~60 FPS
  - ANGLE – ~25 FPS
- Manhattan 3.0 crashed
  - No PBO support

The Productization Journey

Where we ended up 2022

- Khronos dEQP 3.2 conformant (100%)

Samsung Electronics 2022-02-12 OpenGL_ES_3_2	975
Xclipse 920	CPU: ARMv8 OS: Android 12.0 API Pipeline: OpenGL ES 3.2 gl_renderer: ANGLE (Samsung Xclipse 920) on Vulkan 1.1.179 gl_shading_language_version: OpenGL ES GLSL ES 3.20 gl_version: OpenGL ES 3.2

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Vulkan Extensions to Support GLES 3.2

Public Extensions

- VK_EXT_line_rasterization
- VK_EXT_provoking_vertex
- VK_KHR_create_renderpass2
- VK_KHR_fragment_shading_rate
- VK_KHR_incremental_present
- VK_ANDROID_external_memory_android_hardware_buffer
- VK_KHR_sampler_ycbcr_conversion
- VK_EXT_transform_feedback
- VK_EXT_custom_border_color
- VK_EXT_swapchain_colorspace
- VK_KHR_image_format_list
- VK_KHR_surface_protected_capabilities
- VK_KHR_shared_presentable_images
- VK_EXT_depth_clip_control
- VK_EXT_device_memory_report
- …

Vulkan Work-Arounds

- Support for 2D image slices of 3D images to enable EGL_KHR_gl_texture_3D_image
- Support for YUV images as render targets
- Avoided swap-chain acquisition when rasterizer discard is enabled.
- Vulkan pipeline cache statistics feedback to better support ANGLE cache management

Real World App testing with ANGLE Traces

175+ Traces

Image Courtesy of Geoff Lang (Google)

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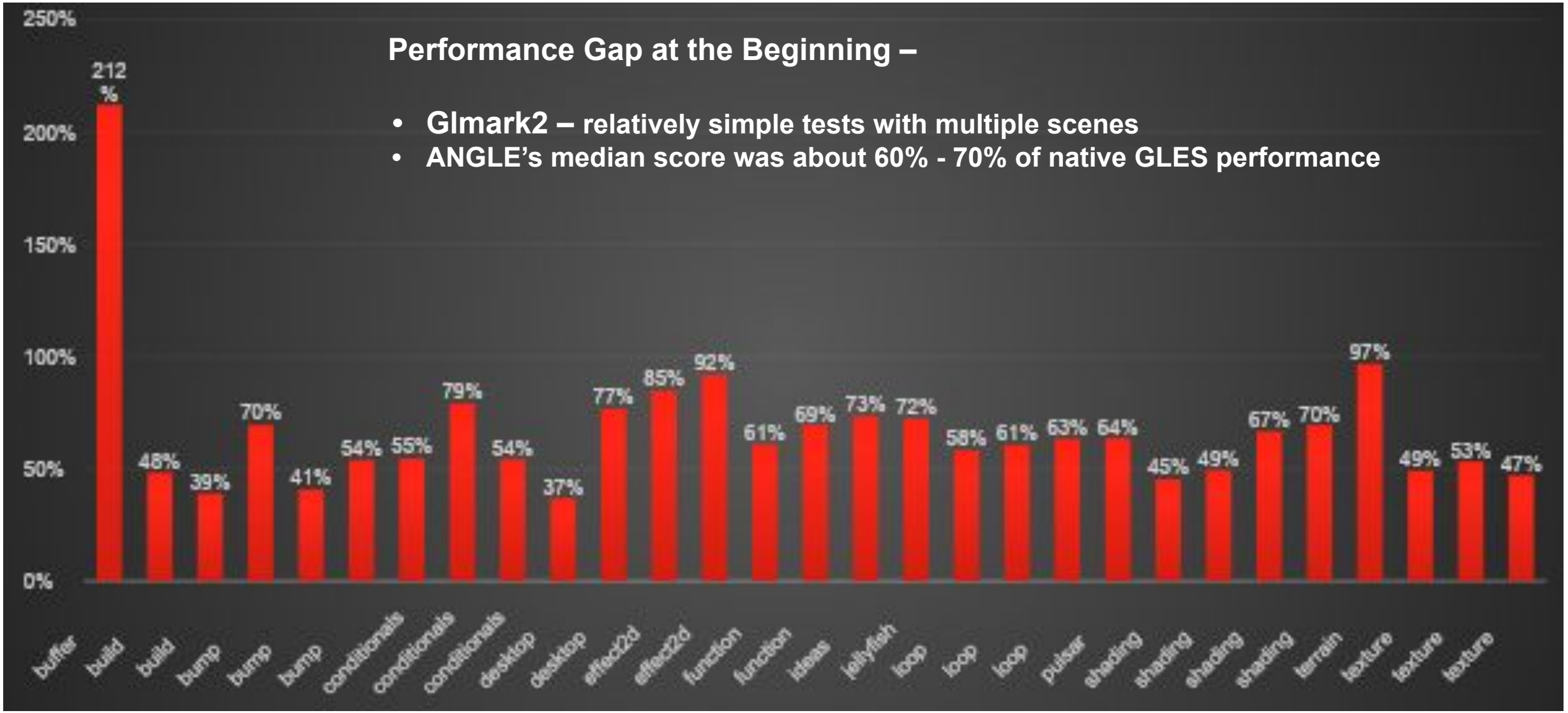
The Performance Story



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The Performance Story

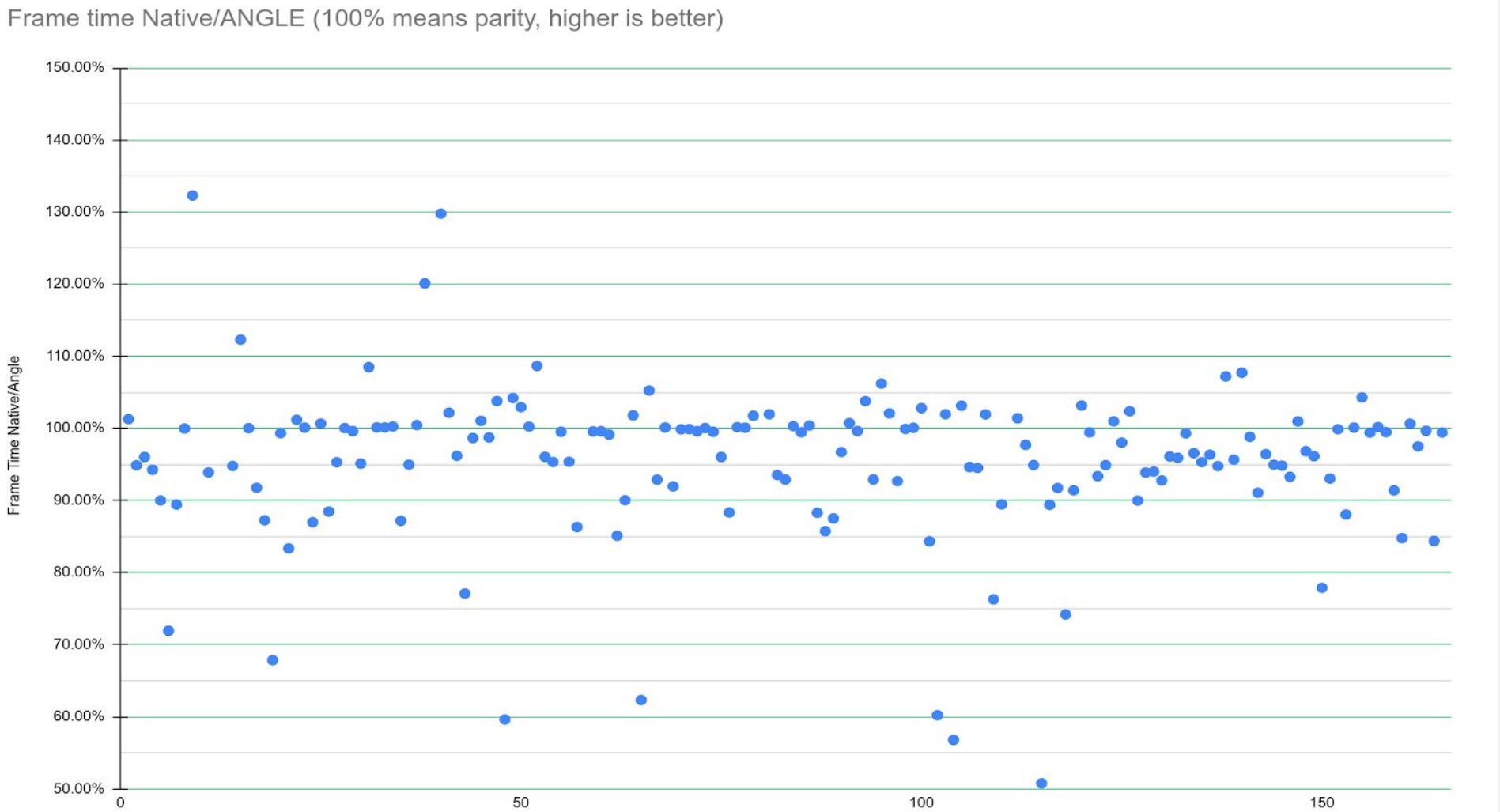
Addressing the performance gaps

- Finer-grained locks (not global) for API entry points
- Mem-pooling and sub-allocations for buffer storage objects
- Early pipeline compilation with “default” state, based on heuristics
- Fast mipmap generation using AMD’s SPD library
- Avoid “vkCmdClearDepthStencilImage” when possible
- Larger pipeline caches supporting LRU-based eviction
- Propagate improved precision of shader-variables
- Remove duplicate texture updates.
- Deferred acquisition of swap-chain images

The Performance Story

Where did we end up?

- ANGLE has about 150 app traces
- Each blue dot is an app trace
- ANGLE perf_test suite provides data about time taken per frame
- 100% means parity with native GLES
  - higher is better



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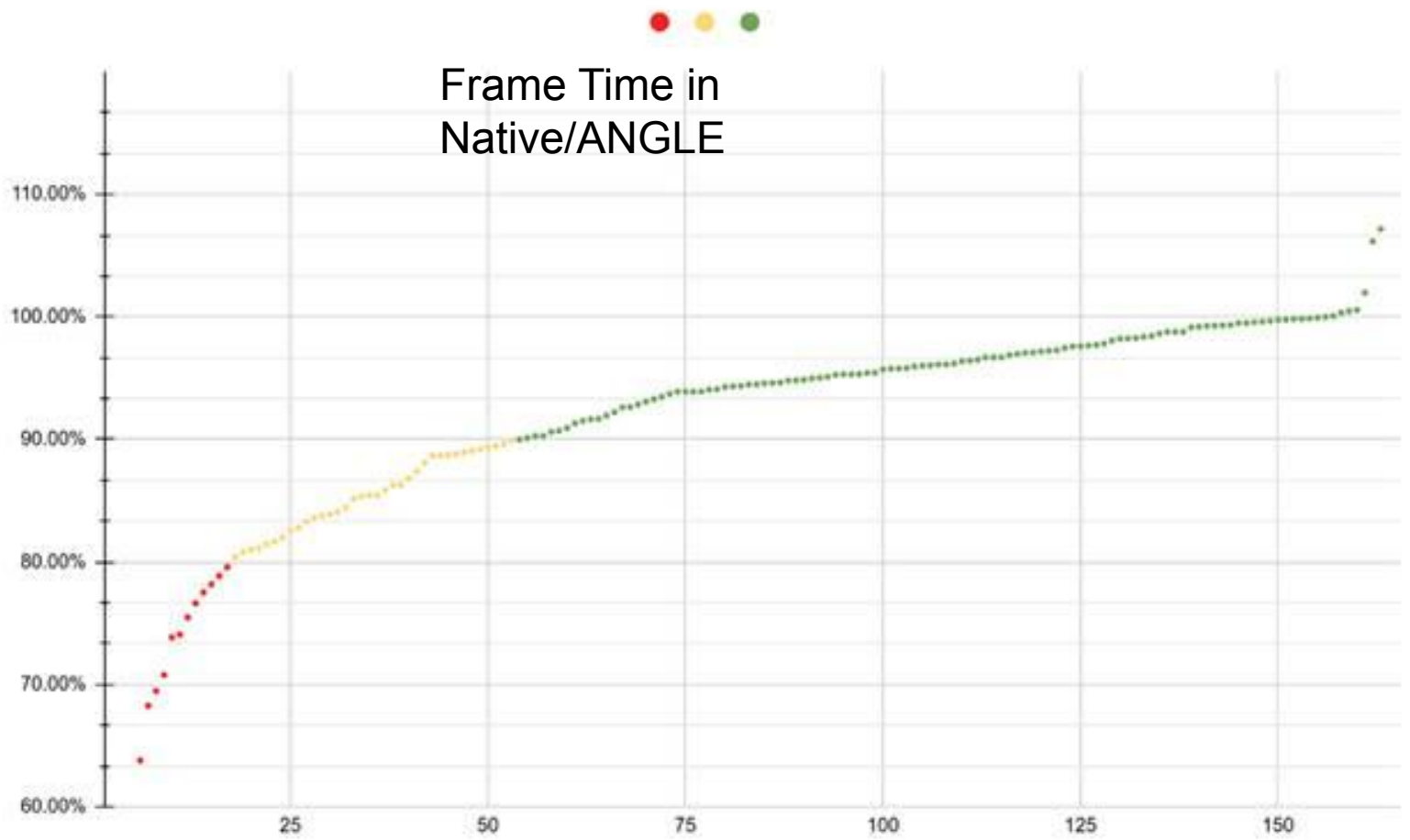


Chart provided by Charlie Lao (Google)

Data is about 3-4 months old

Replacing GLSLANG

Why was this done?

- Old flow with **glslang**:
  - ESSL □ Vulkan compatible GLSL AST □ GLSL String □ glslang □ AST □ SPIR-V
- Flow with **directSpirvGen**:
  - ESSL □ Vulkan compatible GLSL AST □ SPIR-V

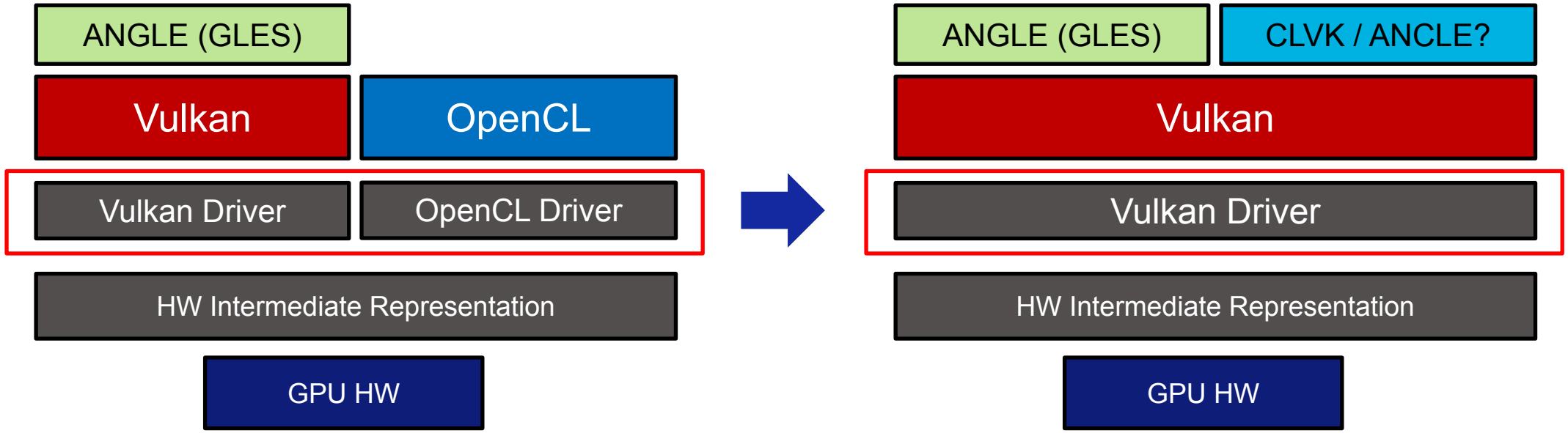
What was the benefit?

- De-duplication of AST transformations
- Removing **glslang** also reduced app startup time because glslang had a large warm-up time.
  - Removed ~20ms of warm-up time for glslang on app start.
- Reduced code size of ANGLE library and decoupled code-churn of the external module
  - Up to 3X reduction in compile time for complex shaders

Future Work

ANGLE and ANDROID

- Progressing towards **Single API** graphics ecosystem
- Removing additional parts for driver/OS upgrade
- Decouple GLES enhancements and bug fixes from OTA graphics driver updates



Q&A