

Bandwidth-efficient graphics

Bandwidth

Where does it go?

- Vertex load
- Varyings
- Textures
- Framebuffer output



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- Varyings
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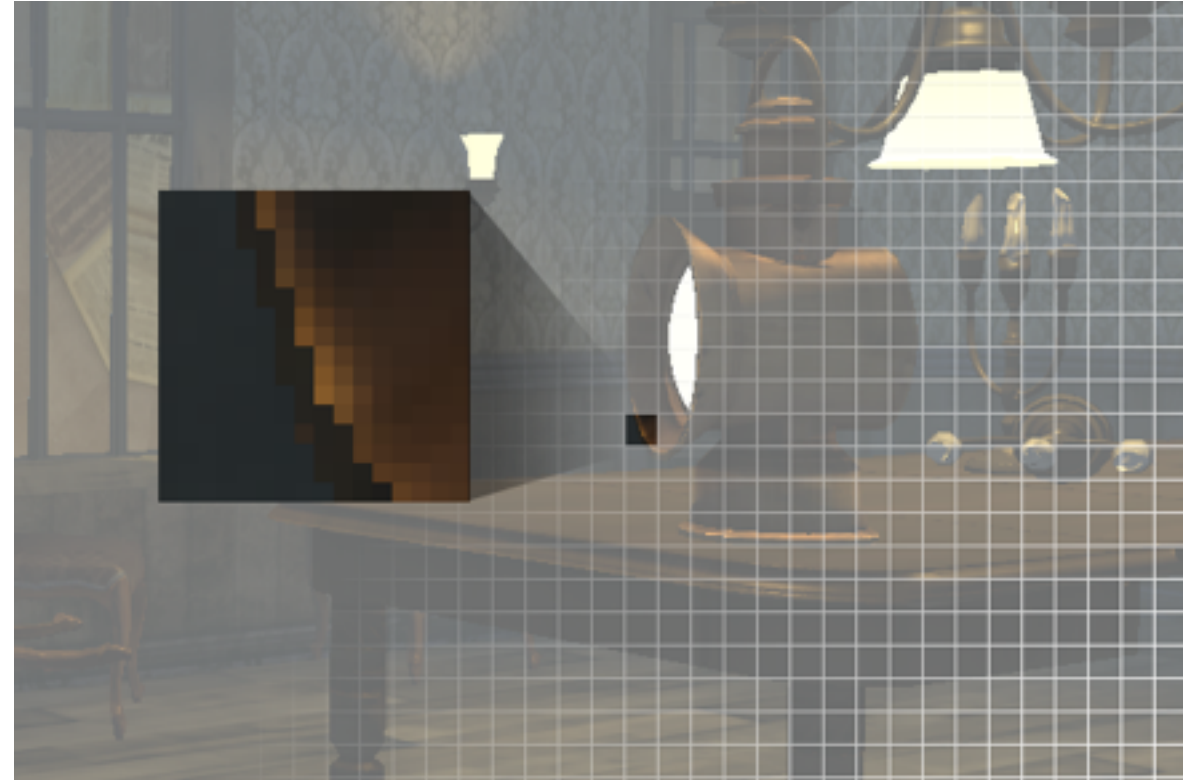
Bandwidth

Where are we?

- Less power = less memory bandwidth
 - Desktop: 170 Watts to >300 Watts... That's just the GPU!
 - Console: 80 - 100 Watts (CPU/GPU/WiFi/Network)
 - Mobile: 3 - 7 Watts (CPU/GPU/Modem/WiFi)
- Need smarter solutions

ARM® Mali™ GPU Rendering

- Mali is a tile-based deferred rendering architecture
 - Framebuffer is divided into tiles
 - Renders tile by tile
 - 16x16 tile size
 - Color
 - Depth
 - Stencil



Extensions

Shader Framebuffer Fetch

- Fragment shader extensions for OpenGL® ES 2.0 and above
- Allows reading of existing framebuffer color, depth and stencil values
- Enables:
 - Programmable blending
 - Programmable depth/stencil testing
 - Soft particles
 - Reconstruction of 3D position
 - etc



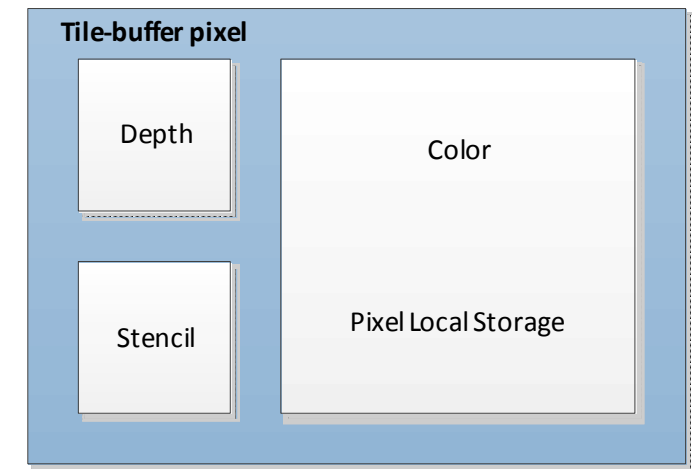
http://www.khronos.org/registry/gles/extensions/ARM/ARM_shader_framebuffer_fetch.txt

http://www.khronos.org/registry/gles/extensions/ARM/ARM_shader_framebuffer_fetch_depth_stencil.txt

Extensions

Shader Pixel Local Storage (PLS)

- Fragment shader extension for OpenGL® ES 3.0 and above
- On the ARM® Mali™ -T600 series this amounts to 128-bits per pixel
 - Mali-T760 can support even more data per pixel
- Enables reading and writing the current pixel's data that is persistent throughout the lifetime of the framebuffer
- Independent of framebuffer format

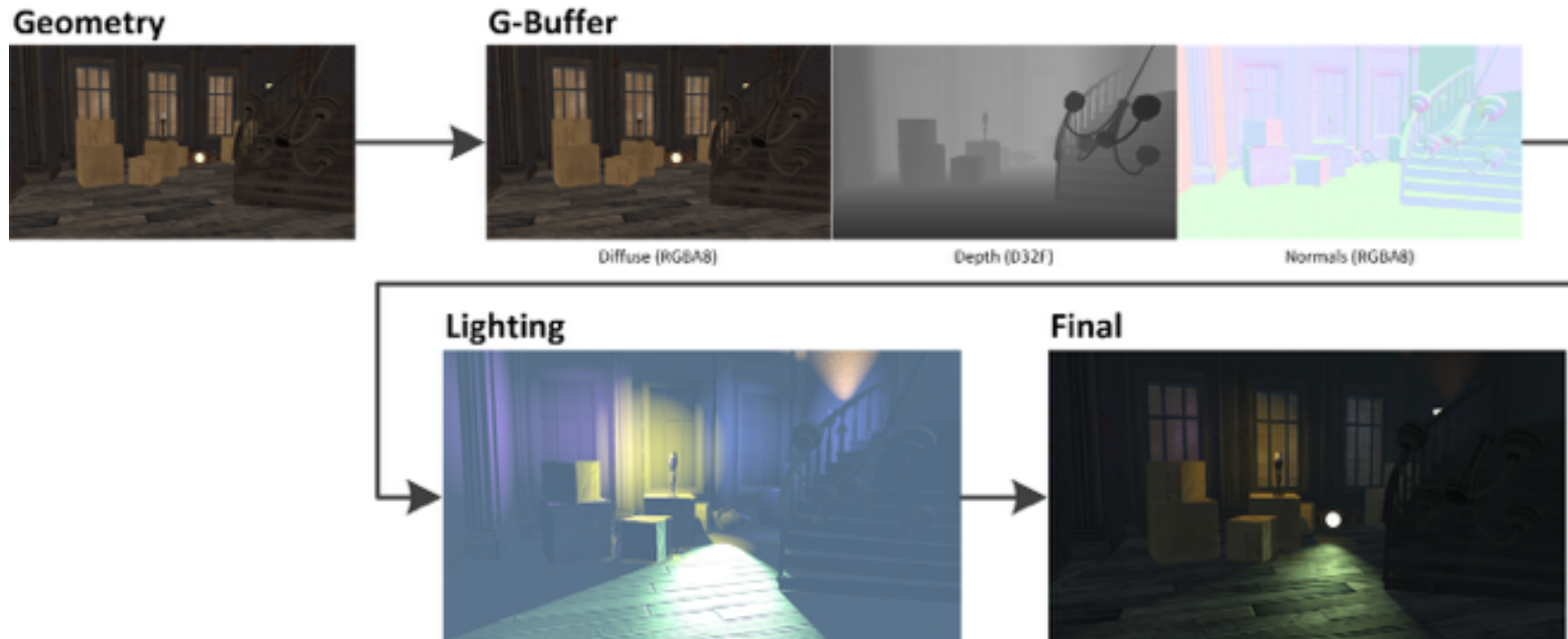


http://www.khronos.org/registry/gles/extensions/EXT/EXT_shader_pixel_local_storage.txt

Deferred Shading

Deferred Shading

- Popular technique on PC and console games
- *Very* memory bandwidth intensive
- Traditionally not a good fit for mobile



Deferred Shading

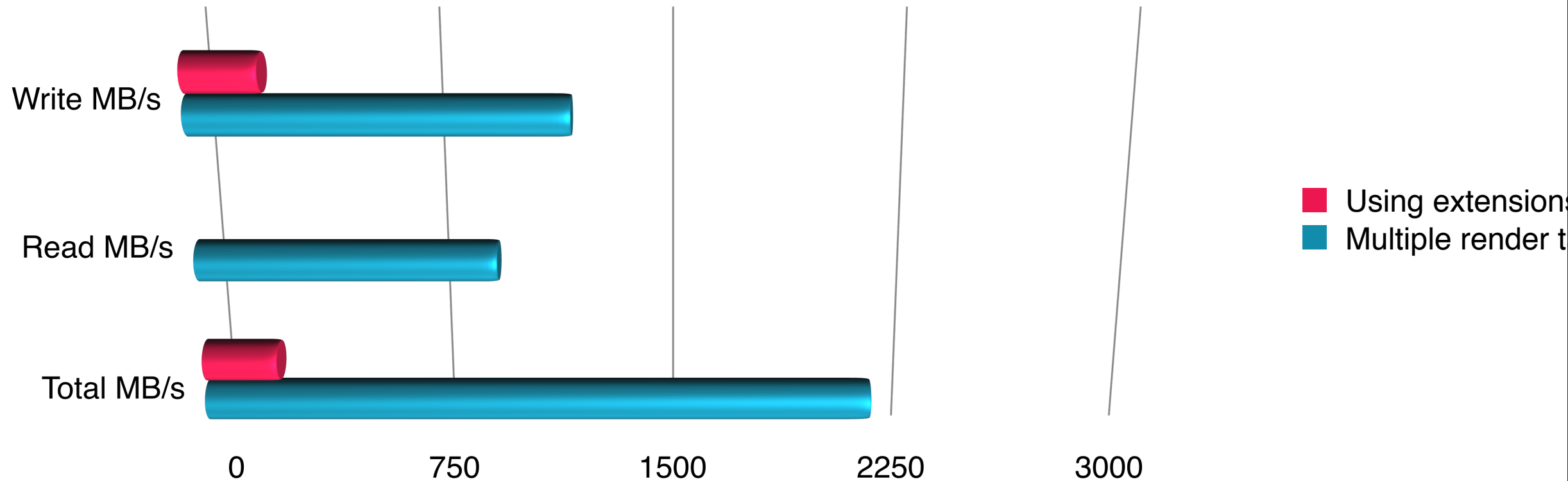
Resolve

- Compute final pixel color based on the Pixel Local Storage data
- Output to current framebuffer format



Deferred Shading

Bandwidth Comparison



deferred shading example
rendering to 4xRGBA8 1080p@30fps

Future

- Various deferred shading/lighting
- Order independent transparency
- Deferred virtual texturing
- Volume rendering
- etc, etc, etc



<http://geomeric.com/downloads/SIGGRAPH-2013-SamMartinEtAl-Challenges.pdf>

Questions?

Thank You

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