Writing Portable OpenGL ES 2.0

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- **Why is this a problem?**
- **What are the key portability issues in OpenGL ES 2.0?**
- **What are the best practices for managing them?**
- **Caveats**
  - Just one spec geek's view
  - Just a beginner's guide

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Portable Graphics: Problem Solved?

- **OpenGL ES 2.0 is everywhere!**
  - iOS
  - Android
  - WebOS
  - Symbian
  - etc

- **So, everything is peachy now, huh?**

  - Sadly, no.

  - Worse, it was done deliberately!

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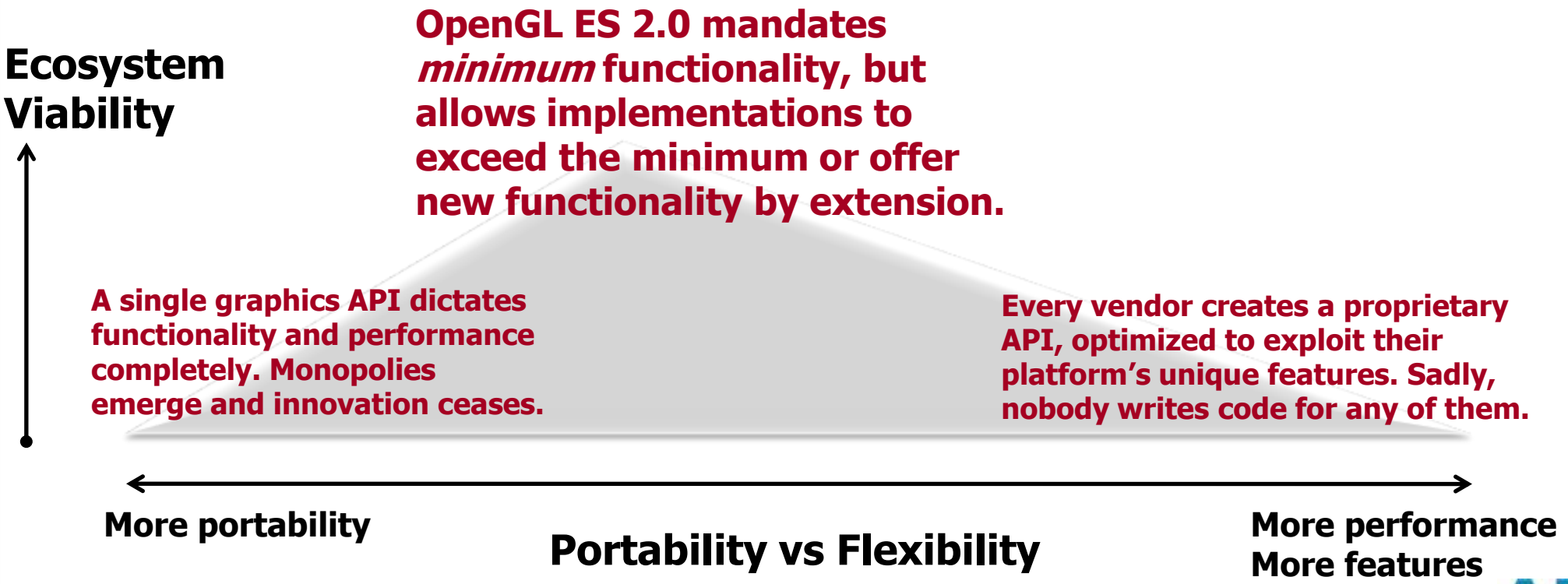
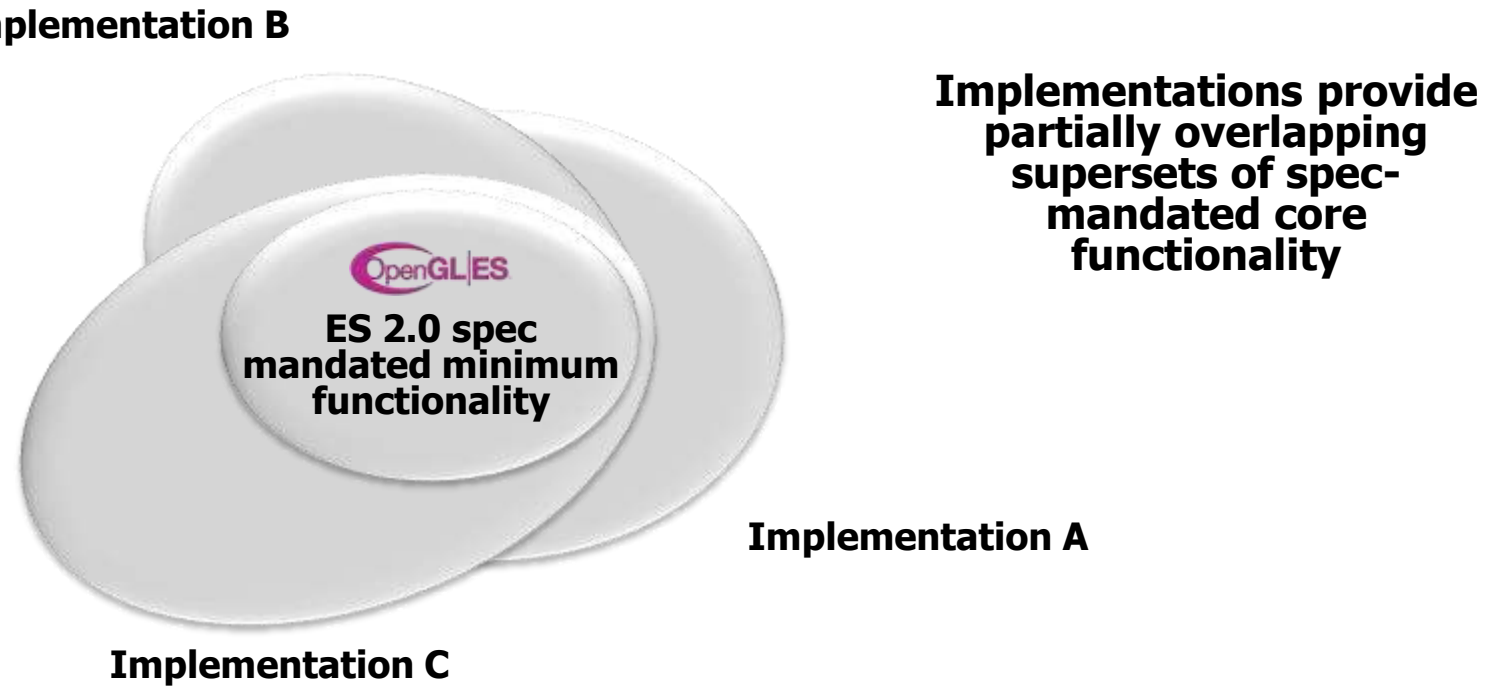
Why isn't this a solved problem?

- Graphics APIs must trade off *portability* against *freedom to innovate*



The One-Slide Guide to Portability



Basic Recommendation

- Design your engine for the portable core
- Then, pull in implementation-specific functionality as time permits or necessity dictates

Portability Issues in OpenGL ES 2.0

- **Performance characteristics**

- **Implementation options**
  - Implementation-defined limits
  - Shader engine arithmetic precision
  - Shading Language restrictions
  - Error Behavior

- **Extensions**
  - Texture compression
  - "Silent" extensions

Performance Characteristics

- **The bad news:**
  - Huge variation even within a single GPU architecture / family
  - Each architecture has different strengths and weaknesses
  - Optimizing for one may hurt you on another

- **Best Practices:**
  - Focus on generic optimizations first
  - Get to know vendor DevRel teams and documents, and test on all your target GPUs early in the development cycle
  - Design your engine to adapt to device performance and capabilities

Implementation-defined limits

- **OpenGL ES 2.0 defines axes along which implementations may differ**
  - E.g., "how many vertex attributes can I use"?
  - Exposed as queriable read-only state, e.g. MAX_VERTEX_ATTRIBS
  - Specification mandates minimum value all implementations must support
    - See specification Table(s) 6.17-6.20

- **Best Practices**
  - Stay within the Chapter 6 minimum-maximum values if you can
  - Or, query and adapt
  - Or, know and respect the maxima for the platforms you target

Shader Engine Arithmetic Precision

- **GLSL ES allows you to apply precision qualifiers to variables**
  - Lowp (10-bit), mediump (16-bit), highp (24-bit)

- **Qualifiers specify the minimum precision that must be provided**
  - Implementations can provide more than you ask for
  - You can query via `GetShaderPrecisionFormat()`

- **Support for highp is *optional* in the fragment shader**

- **Best Practices**
  - Watch out for: large texture wrap factors, sensitive reflection vectors
  - Declare `#precision float mediump` in your fragment shader
    - If you use highp, provide a fallback for implementations that don't support it
  - Test on implementations that (really) don't provide highp

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Shading Language Restrictions

- **GLSL ES 1.0 allows implementations to provide less-than-full support for the core shading language**
  - No virtualization – compilation can fail due to "out of resources"
  - Loop bounds may have to be known at compile time
  - Implementations may have restrictions on indexing
    - May require indices to be compile-time constants
  - See GLSL ES 1.0 specification, Appendix A

- **Many vendors relax some of these restrictions, but there is no query**

- **Best Practices**
  - Stay within Appendix A guidelines, or be prepared to fall back
  - Import vendor off-line shader compilers into your shader development pipe

Bad Code is Bad for Portability

- **Invalid pointers**
  - Attribute buffers
- **Shading Language Errors**
  - Divide by zero
  - NaN generation / propagation
- **API restrictions**
  - TexImage2D type / format / internalformat restrictions

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Extensions

- **Implementations can advertise novel features via *extension specs***
  - Defined as deltas to the core spec – can add features but not remove them
  - E.g., `OES_texture_npot`
  - Query using GetString[v]()

- **Categories**
  - OES: Written and approved by the ES Working Group, ratified, conformance tested
  - EXT: Supported by multiple vendors
  - Vendor (e.g. ARM): Supported by a single vendor, possibly proprietary

- **Best Practices**
  - AVOID if you can
  - If you use, prefer OES to EXT to Vendor
  - Always query and adapt

Texture Compression

- **Texture compression is great! Use it!**
  - Formats: ETC1, PVRTC, DXTn, …
- **The bad news:**
  - There are no universally supported formats
  - To target both iOS and Android, you will need at least two art paths
- **Best Practices**
  - On iOS: Use PVRTC (vendor extension)
  - Everywhere else:
    - Use ETC1 (OES extension) if you can
    - Or, query for other vendor extensions

Photo: http://www.dicts.info

Fun with ETC1 textures

- **ETC1 is RGB-only. What if I need RGBA?**
  - Use two channels of ETC1
    - Second texture fetch is often free
    - If not using wrapping, pack RGB and A images into an atlas
  - Or, use ETC1 for RGB and pack A into another texture
    - E.g. use LA88 to store a height map plus alpha
- **What about normals?**
  - Use two channels of ETC1
- **In general, ETC1 has excellent resolution in luminance**
  - Works well when R/G/B are highly correlated

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"Silent" Extensions

- **OpenGL ES 2.0 restricts certain convenience features of OpenGL**

- **Example:** `glTexImage2D(T, L, internalformat, W, H, B, format, type, d);`
  - In ES, *format* must match *internalformat*

- **Rules are not well tested by the ES conformance test**
  - Some implementations allow features that they shouldn't

- **Best Practices**
  - Know the rules
  - Yell at ES 2.0 implementors who break them
  - (I'll help)

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Summary

- **Writing portable OpenGL ES 2.0 is challenging!**
  - It's the price we pay for rapid evolution of the technology
- **To manage the beast:**
  - Design for the portable core of the API
  - Know the specification
  - Debug your code
  - Don't use implementation-specific features if you can avoid it
  - Know (and test on) all of the major implementations
- **Good luck!**

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Acknowledgements

- **Thanks to:**
  - Maurice Ribble (Qualcomm)
  - Daniel Koch (Transgaming)
  - Acorn Pooley (NVidia)
  - Anders Lassen (ARM)
  - Jan-Harald Fredricksen (ARM)
  - Jakub Lamik (ARM)
  - Ed Plowman (ARM)
  - Rob Simpson (Qualcomm)

- **Feedback gratefully accepted at**
  - http://www.khronos.org/bugzilla/

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