DEVELOPER SUMMIT

March 10–13

WELCOME

ArcGIS Runtime SDKs: Core Display Architecture Performance Tips and Tricks

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WARNING!

The following presentation and demos have been rated as Extremely Nerdy and contains information that is not suitable for some viewers

EXTREMELY NERDY

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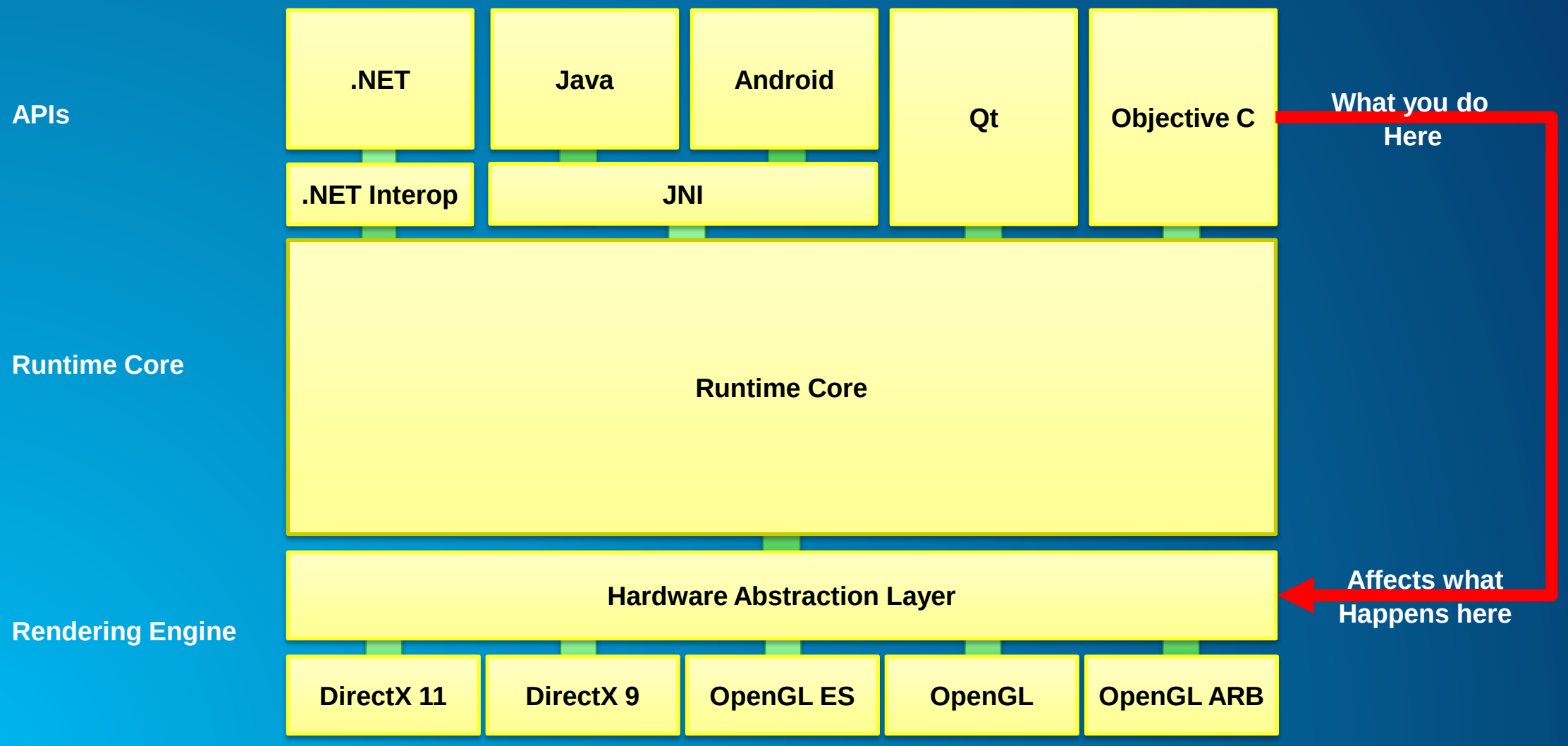
What We Will Cover Today

- Dive deep into the guts of the ArcGIS Runtime Rendering Engine
  - Use NVIDIA Nsight to see how rendering works
  - Once you understand the way the Runtime renders data you can make the right decisions for your application and target device
- General tips for overall performance gains with rendering in the Runtime
- Focus of this presentation is providing you with the knowledge to build high performance ArcGIS Runtime Apps

What is the ArcGIS Runtime?

- Set of APIs for building native applications on a wide range of platforms
- Built on a single C++ codebase compiled natively for each platform
  - No platform dependency (no COM)
  - Allows us to leverage the platform to maximize performance
  - Build functionality once and use it everywhere
- Rendering Engine
  - OpenGL, OpenGL ARB Assembly Language, OpenGL ES 2.0, DirectX 9, DirectX 11
  - Rendering selected for platform for optimal performance
  - Designed to work with both Desktop and Mobile Devices

Understanding the ArcGIS Runtime Architecture



Core Rendering Modes

- Static
  - Tiled Layers, Dynamic Map Service Layers, Feature and Graphics Layers (option)
  - Images are converted to textures
  - Textures are rendered on the GPU
- Dynamic
  - Feature and Graphics Layers (option), Grid Layer, Label Layer, GPS Layer
  - Symbols are converted to textures
  - Geometries are converted to triangles and texturized at render time

DEMO

ArcGIS Runtime Rendering Modes

Why different modes?

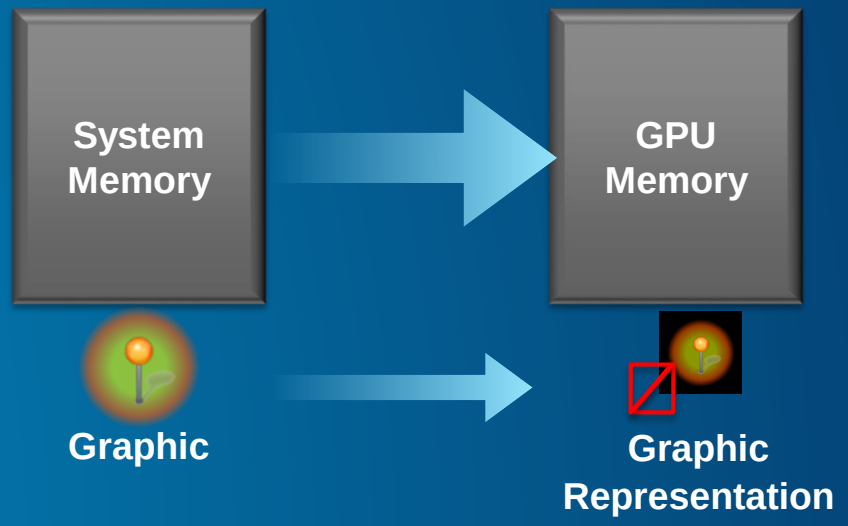
- We are building a GIS solution
- We don’t know the data ahead of time
- Must support a variety of use cases and workflows
- Performance is paramount
  - You choose the right mode for your use case and device

Graphics Processor Basics – What you should know

- Graphics card contains a dedicated processor (GPU) and memory which allows us to offload work from the CPU
  - Designed to perform complex rendering calculations
  - Produces less heat and uses less power than the CPU
- Execution occurs asynchronously until a state change is necessary
  - Runtime example: drawing points to drawing lines
  - When a state change occurs the GPU flushes the existing pipe
  - We batch as many things as we can to minimize this and keep the UI interactive
- Runtime renders by creating textures and triangles
  - We generate textures in many different ways depending on the layer

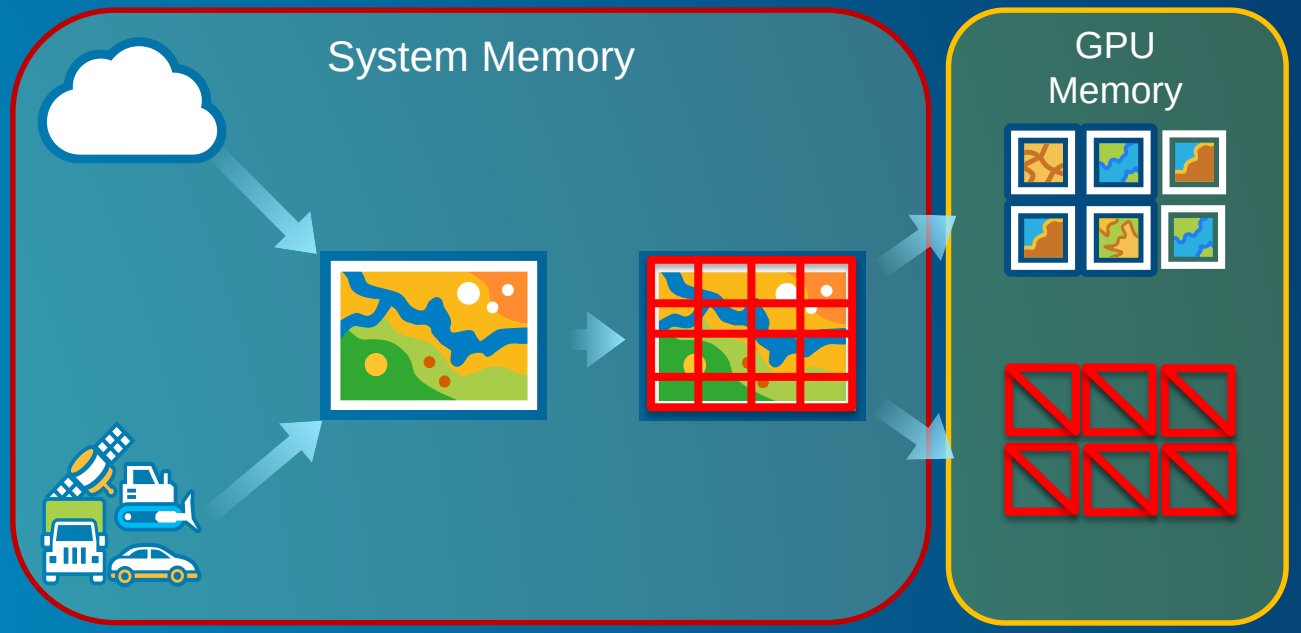
Graphics Processor Basics – What you should know

- Runtime data is stored in both system memory and graphics card memory
- Switching from system memory to GPU memory has a performance cost
  - Knowing when and how this occurs can help you build a high performance app
- Once data is in GPU memory rendering is fairly cheap
- Rendering Modes directly impact
  - Where data is stored
  - When and how it gets transferred
    - Runtime optimizes this as much as possible



Static Mode Rendering Explained

- Collections of Graphics on System Memory (Geometry and Symbol)
  - Graphics rendered as paths onto an image
- Or receive images from another source (Cloud or a TPK)
- Image is broken into blocks for partial updates
- Blocks are converted into textures for the GPU to render
- Triangles are created based on textures for proper placement



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Deep Dive into the Static Rendering Mode

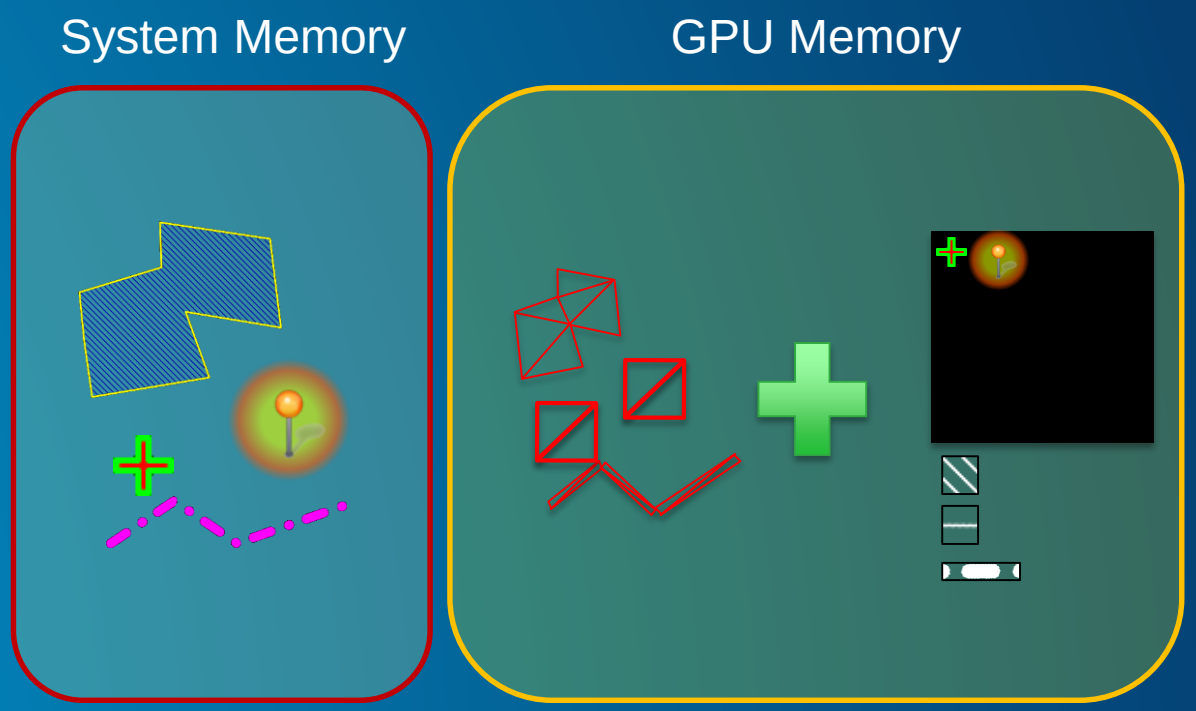
Static Mode Summary

- Designed for cartographic quality
  - Whole graphic is rendered as a path
- Scales up well
  - Only regenerate textures when we need to (passive rendering)
  - Increasing or decreasing the number of graphics within a layer does not affect number of textures on the GPU

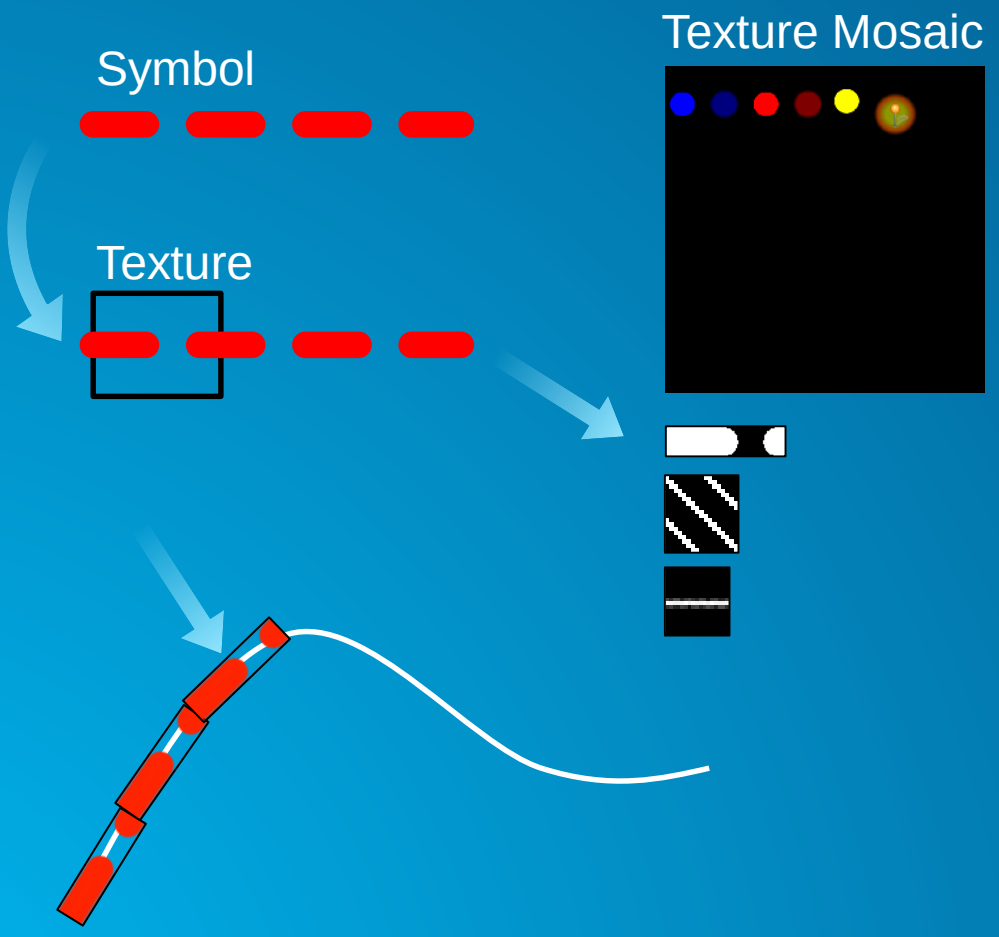
- Can be system memory intensive
- Updates to graphics require redraws of the image
- View changes require full or partial updates to image
- Rendering primarily done through CPU

Dynamic Rendering Mode

- Collections of Graphics on System Memory
- Symbol converted to textures and stored in a texture mosaic on the GPU
- Geometries are converted to triangles
- At render time the textures are applied to the triangles



Dynamic Mode Symbol Rendering



- Textures are created from the symbols
- Points symbols pushed to the texture map
- Lines and Polygons symbols
  - Snapshot of the the symbol pattern
- Texture is overlaid on the geometry
  - Extremely fast
- For simple symbols color can be applied at render time

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Deep Dive into the Dynamic Rendering Mode

Dynamic Mode Summary

- Entire graphic representation lives on the GPU
  - No CPU update required when panning, zooming, or rotating the map
- Some graphic changes can be applied directly to the GPU state
  - Like moving and animating
- Graphics can remain screen aligned while map is rotating

- Number of and complexity of graphics can impact GPU resources
- Symbology could look a little different
  - Performance is the priority
- Devices do have a finite amount of texture memory

Graphics and Feature Layers – Which Mode Should I Use?

- Number of Graphics vs GPU memory and power
  - Static Mode creates the same number of textures regardless of number of graphics
  - Dynamic Mode graphics live in GPU memory, more graphics, more GPU work
- Battery Life
  - Static CPU – Dynamic GPU
  - GPU is much more efficient with battery life
- What is the tipping point?
  - Depends on the use case, data, and the target device

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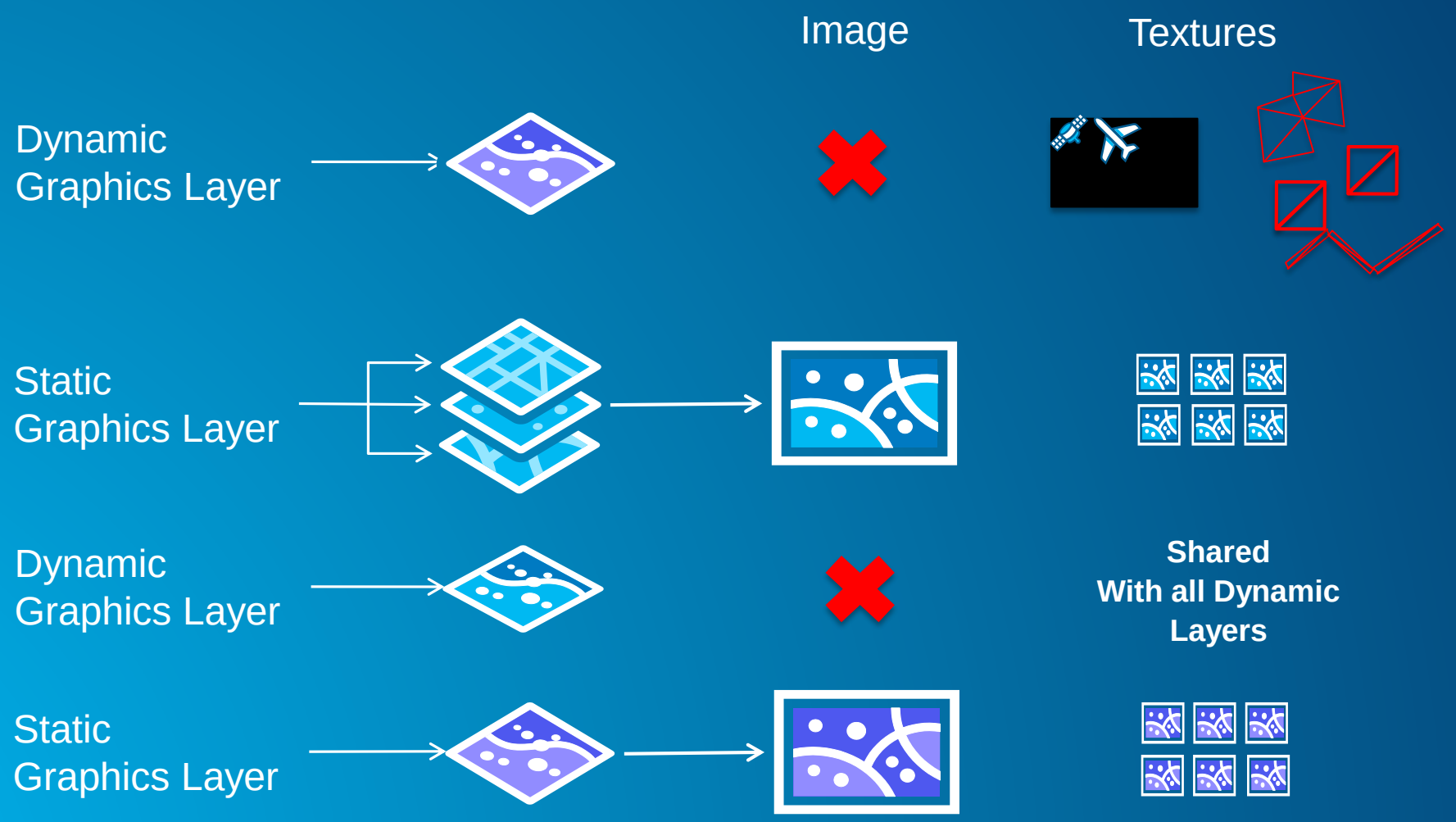
Static and Dynamic Rendering Modes

1 Graphic vs 10,000 Graphics

Graphics and Feature Layers – Which mode should I use?

- Dynamic mode
  - Number and order of layers not as important
  - Resources are shared between all layers on the GPU
- Static Mode
  - Number and order of layers matters
  - Layer ordering can affect resource sharing
- Core will consolidate layers whenever possible
  - Minimize textures
  - Optimize system memory usage

Static Mode Layer Consolidation



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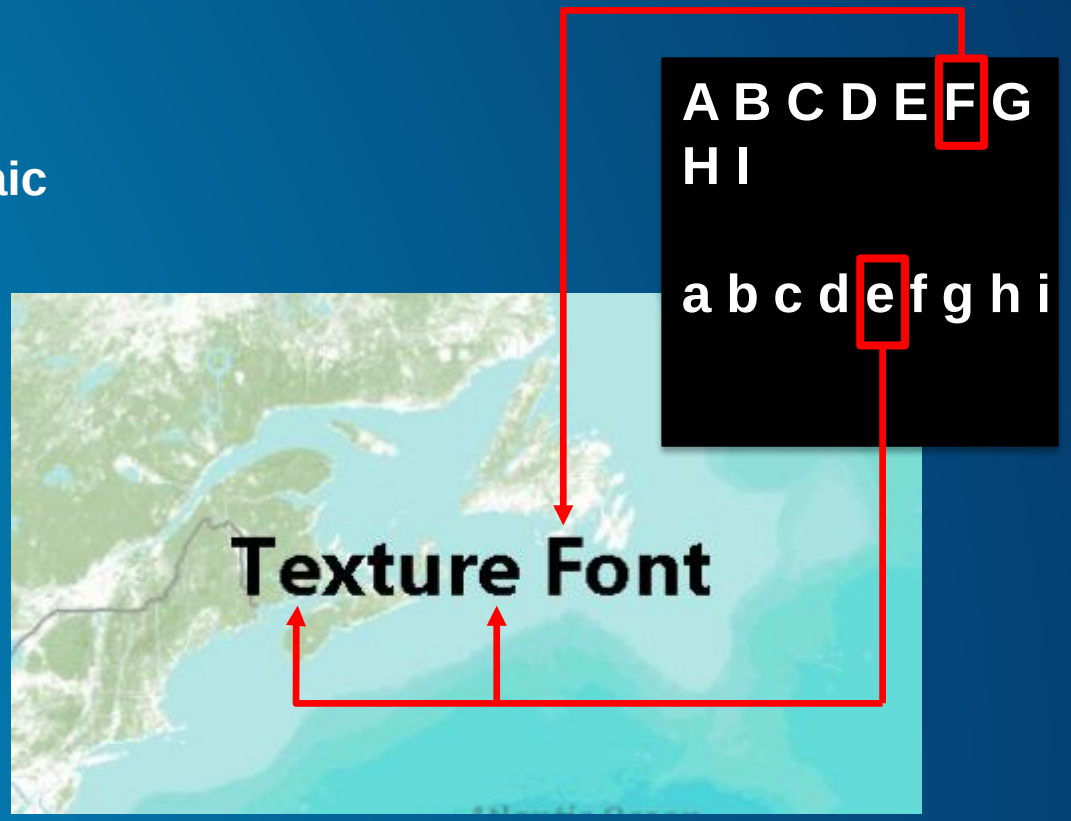
Static Mode Layer Consolidation

Text Rendering

- Static Mode
  - Text Rendered Directly to the Image
- Dynamic Mode
  - New in 10.2.4! Texture Fonts
  - Fonts converted to Glyphs onto the Texture Mosaic
  - Glyphs can be reused for all Text Symbols



Text Symbols – Which mode should I use?

- Cannot choose mode with labeling
  - Labels are dynamic – move, appear, disappear
  - Point and Polygon labels tend to be screen aligned
    - Only Dynamic Mode can do this effectively
- Static Mode
  - Static Text, lots of fonts, size changes
  - Concerned about Texture Memory
- Dynamic Mode
  - Same font and size
  - Label like effect when panning and zooming

Graphics and Feature Layers – Which mode should I use?

- Dynamic Mode
  - Geometries are converted to triangles (vertices)
  - My require additional vertices to be generated to properly represent the geometry than the original feature contained
  - Polygons also have outlines which need to be converted to vertices
  - Both of these require additional GPU resources to represent the data
  - Will require 2 draw operations to render a single polygon
- Static Mode
  - Number of textures are always the same
- Complexity of your geometry has an impact on performance

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Complex Polygon

Graphics and Feature Layers – Which mode should I use?

- **Static or Dynamic - Is there a rule I can follow with polygons?**
  - **Depends on the number of polygons and the device**
  - **Multiple large features with millions of vertices with bring even the strongest GPU to its knees**

Graphics and Feature Layers – Best Practices

- Static Mode
  - Is best for Feature Services
    - Unknown number of features
    - Unknown symbols
    - Unknown geometry complexity
- Dynamic Mode
  - Sketch or interactive layers
  - Real-time feeds with rapid updates
  - Points

Additional Tips for Improved Performance

- When adding and creating graphics use arrays
- Use a renderer whenever possible instead of individual symbols for each graphic
  - Avoids additional logic in core to handle duplicate symbols
- Create a new layer for each geometry type
  - Affects Dynamic Mode not Static mode
- Avoid layer level transparency
  - Requires additional draw operations and texture generation
  - Stick with symbol level transparency whenever possible
  - This also applies to other static layer drawing

Transparency

Symbol Level

Layer Level

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Performance Tips

What new for the Quartz Release?

- Hardware Abstraction Layer Performance Optimizations
- Additional DX11 functionality
- OpenGL 4.3 (Desktop) and OpenGL ES 3.1 (Mobile)
  - If available we'll use it
  - Better performance
  - 3D support
- Compute Shaders
  - Real-time GPU Driven Spatial Analysis
- Vector Tiles
  - High performance Base Maps

It's shiny…

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Sneak Peek

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