Esri International Developer Summit

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Squeezing Every Ounce of Performance from ArcGIS Runtime

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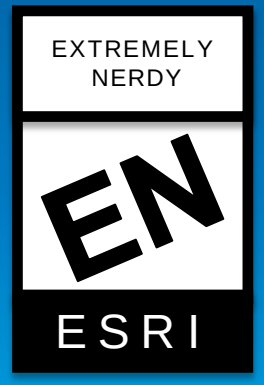
WARNING!

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



MPL: Multiple Programming Languages
RCE: Runtime Core Exposure
NT: Nerdy Terminology

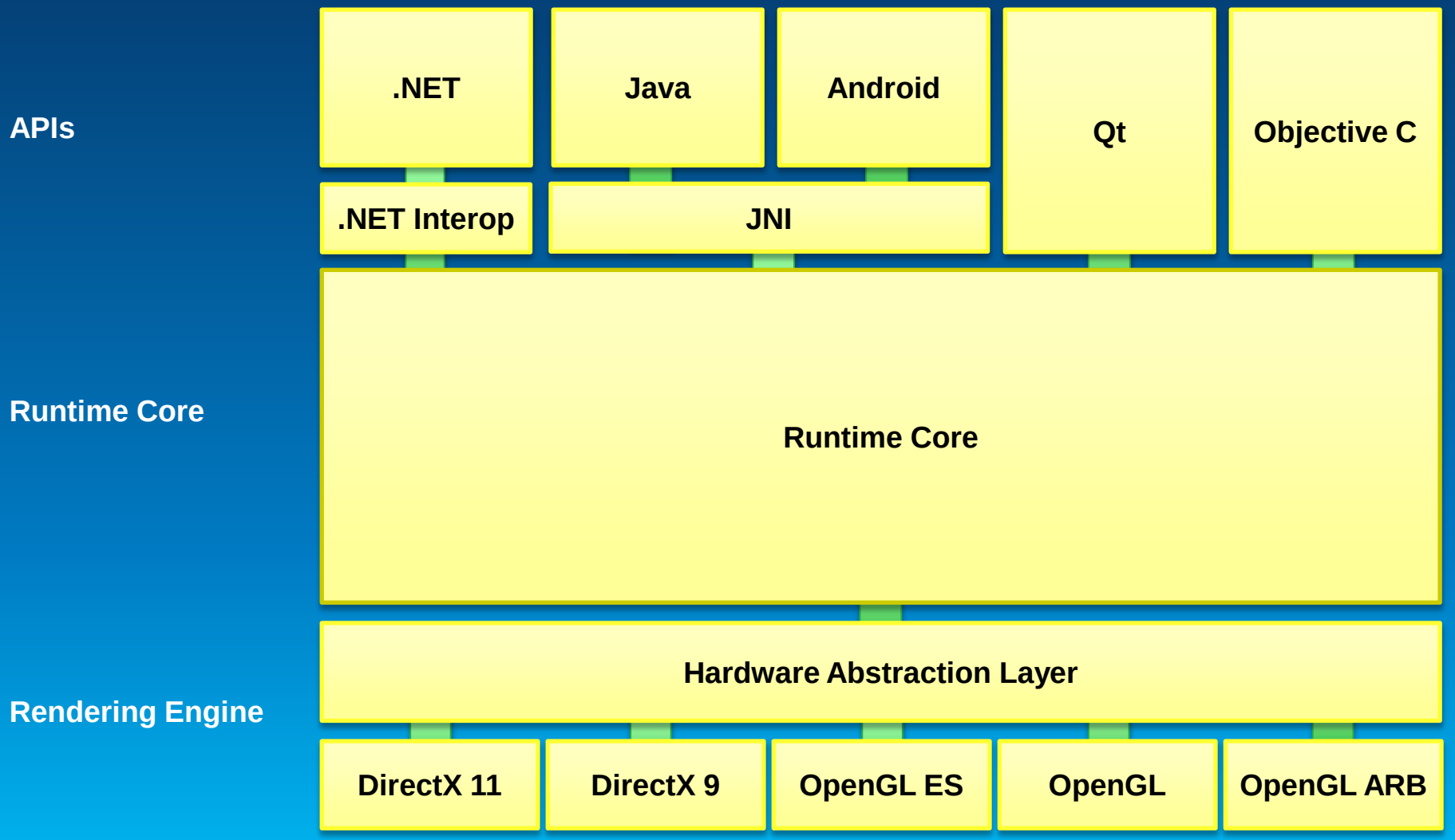
What We Will Cover Today

- Focus of the presentation is on building high performance ArcGIS Runtime Apps
- Deep dive 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 in the Runtime

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
    - Powerful Desktop Graphics Cards
      - NVIDIA, AMD, Intel
    - Heat and battery efficient Graphical Processor Units (GPUs)
      - Many render differently than desktop GPUs

Understanding the ArcGIS Runtime Architecture



Graphics Card Basics – What you should know

- Graphics card contains a dedicated processor (GPU) and memory which allows us to offload work from the CPU
  - GPU is designed to perform complex rendering calculations
- 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 Card 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 in GPU memory rendering is fairly cheap
- Some layers have different Rendering Modes
  - Rendering mode has a direct impact on where data is stored

Core Rendering Modes

- Static
  - Tiled Layer, 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

Why different modes?

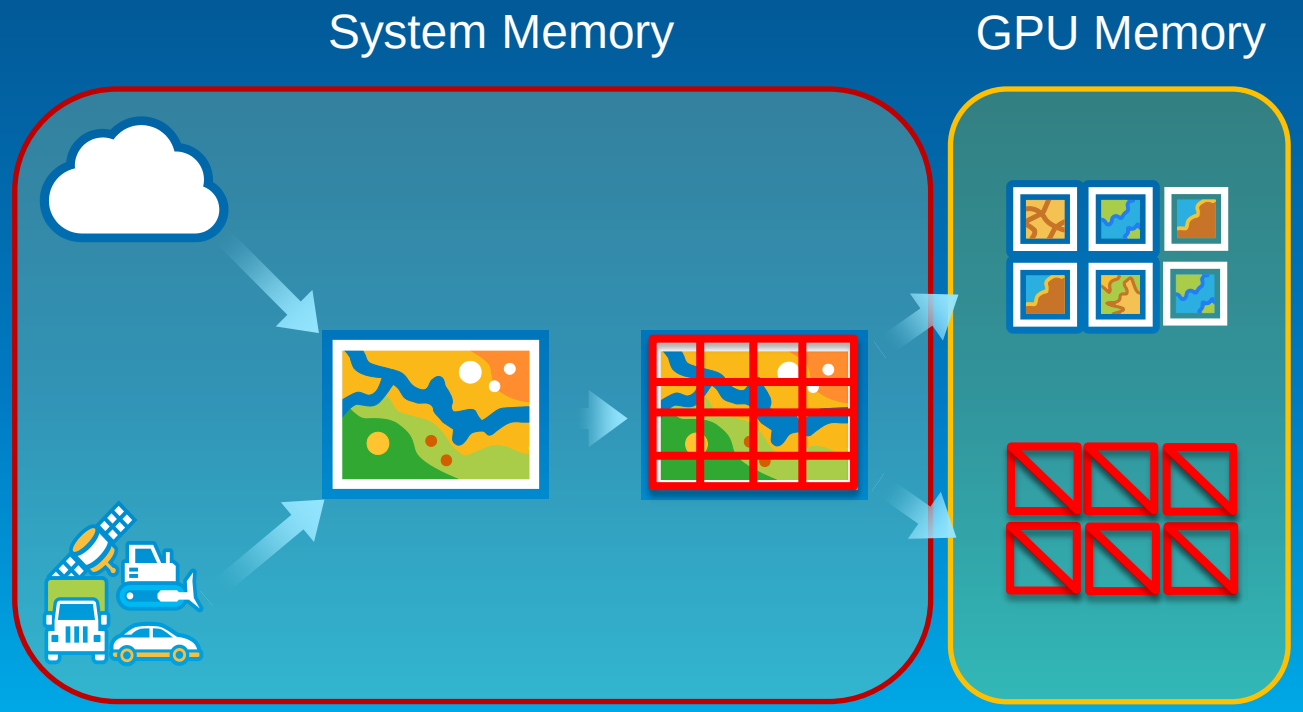
- We are building a GIS solution
- We don’t know the data ahead of time
- Must support a variety of use cases and workflows
- Performance is paramount
  - You choose the right mode for your use case and device

DEMO

ArcGIS Runtime Rendering Modes

Static Mode Rendering Explained

- Collections of Graphics on System Memory (Geometry and Symbol)
  - Path rendered onto image
- Image is broken into blocks for partial updates
- Blocks are converted into textures for the GPU to render
- Triangles are created based on textures



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Deep Dive into Static Rendering Mode

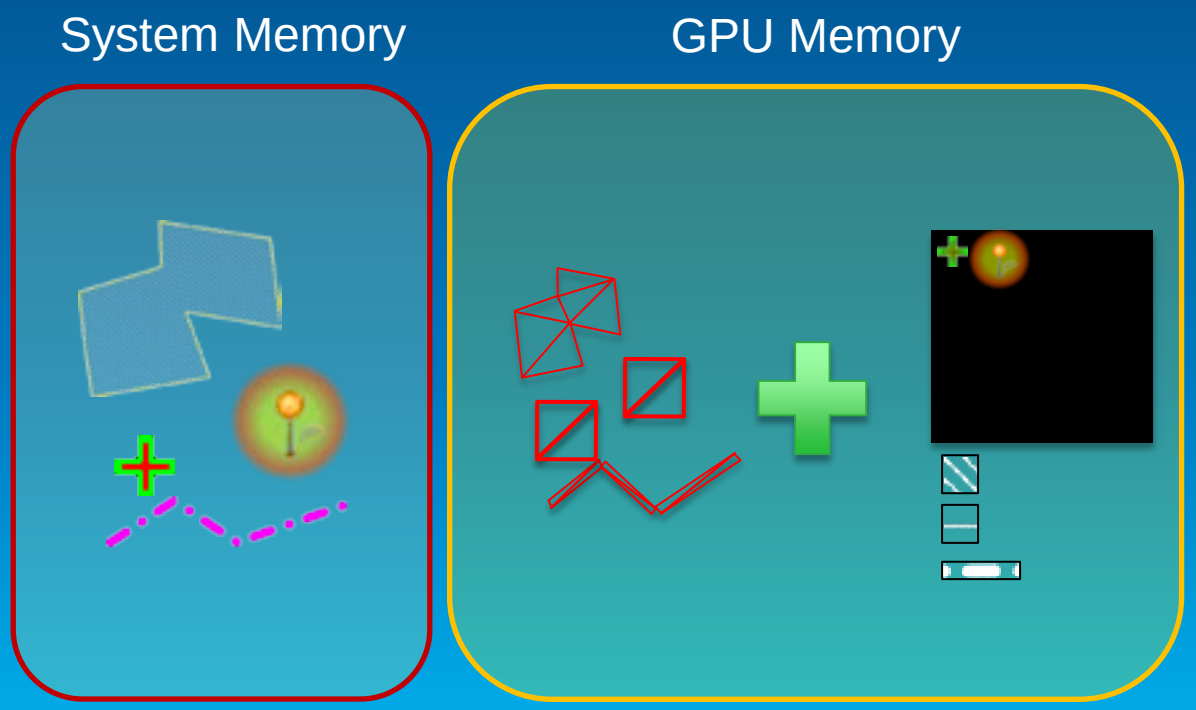
Static Mode Summary

- Designed for cartographic quality
  - Whole graphic is rendered as a path
- Scales up well
  - Increasing or decreasing the number of graphics within a layer does not affect number of textures on the GPU

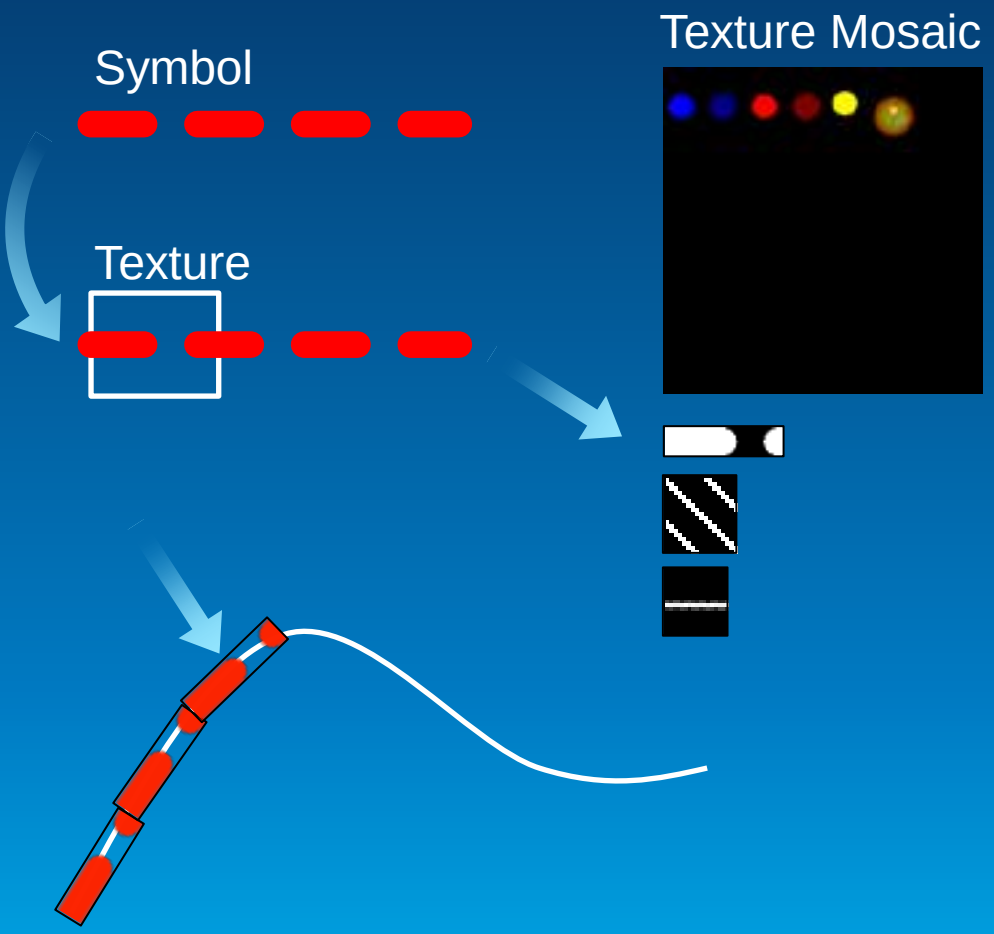
- Can be system memory intensive
- Updates to graphics require redraws of the image
- View changes require full or partial updates to image
- Rendering primarily done through CPU

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
- Simple symbols
  - Color can be applied at render time

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Deep Dive into 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 and complexity of graphics can impact GPU resources
- Symbology could look a little different
  - Performance is the priority

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
- Graphics in Dynamic Mode live in GPU memory
- What is the tipping point?
  - Depends on the use case, data, and the target device
  - All comes down to user interaction and use case

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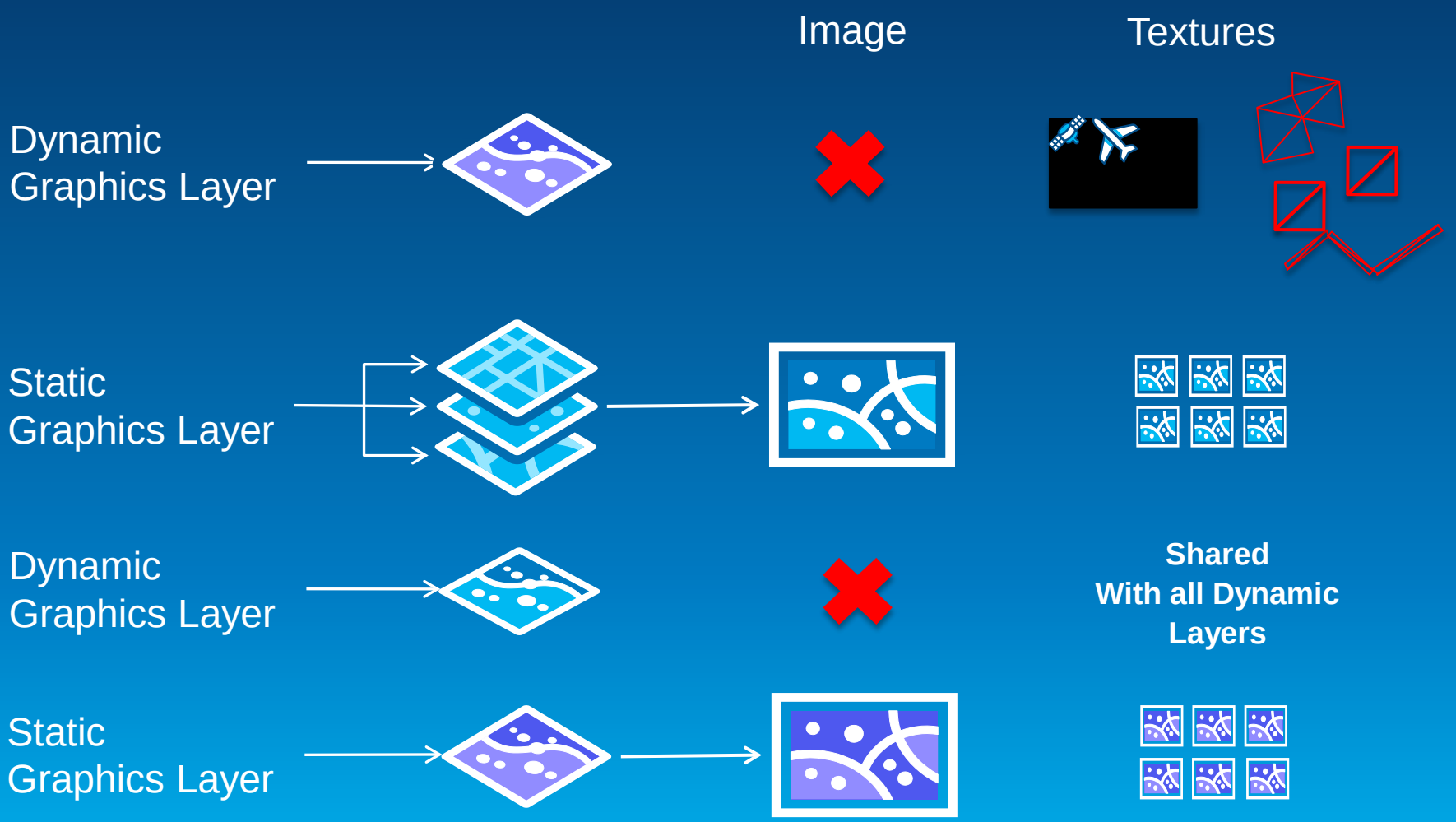
Static and Dynamic Rendering Mode

1 Graphic vs 10,000 Graphics

Graphics and Feature Layers – Which mode should I use?

- Core will consolidate layers whenever possible for maximum performance
- 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
  - Each layer renders to an image
  - Layer ordering can affect resource sharing

Static Mode Consolidation



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Graphics Layer Static Mode Consolidation

Graphics and Feature Layers – Which mode should I use?

- Complexity of your geometry
- In Dynamic Mode geometries are converted to triangles (vertices)
  - My require additional vertices to be generated to properly represent the geometry
- 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

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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 symbol and 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

Transparency

Symbol Level

Layer Level

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Batching

10.2.2 Performance Enhancements

- Internally calling move when setting a new geometry on a point
  - Prevents regeneration of triangles
  - Just reposition geometry on graphics card
- Reduced number of instructions to GPU
- Reduced context switching on GPU
- Added more low level batching functionality
- Better reuse of resources and vertices

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