GameDevelopers Conference Mobile 08

CMP

Next-Gen Tile-Based GPUs

February 18-22, 2008
San Francisco

Maurice Ribble

AMD

The Agenda

- Introduction to tile based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

The Agenda

- Introduction to tiling based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

The Need in the Mobile Market

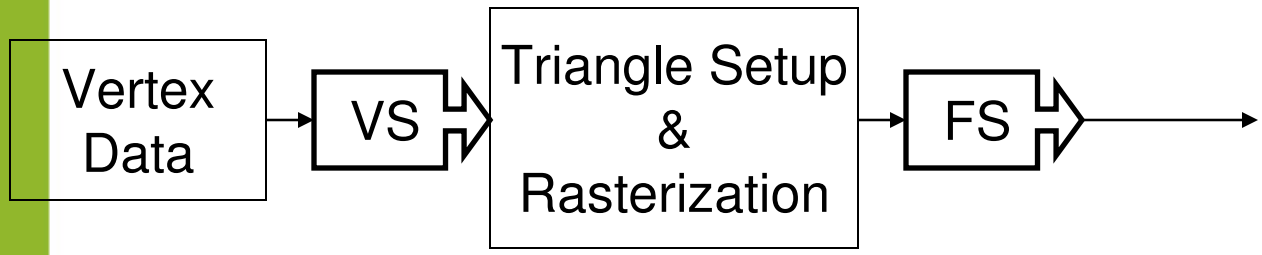
- Solution to the limited bandwidth problem
- Low power (better battery life)
- Small size (cheap)
- Good performance
- Flexible shaders

Traditional Graphics Pipeline vs TBR Pipeline

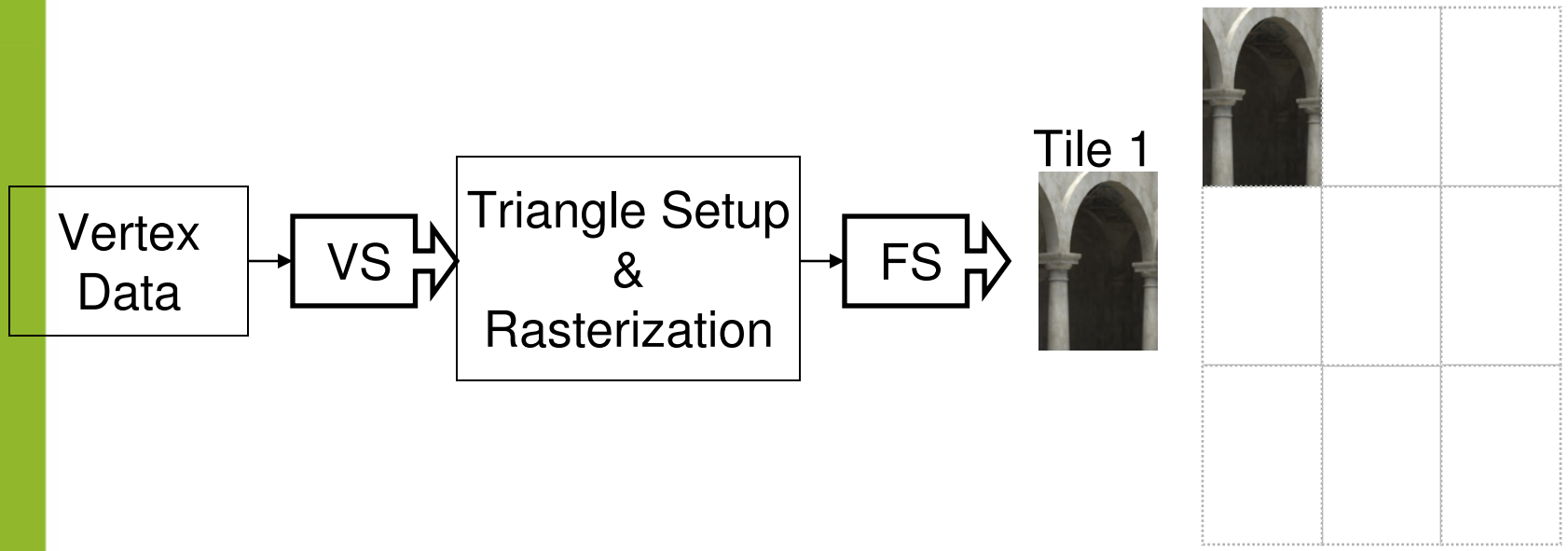
- TBR = Tile-Based Rendering

- Traditional GPUs render full scene in one pass
- Tiling GPUs render scene in multiple passes

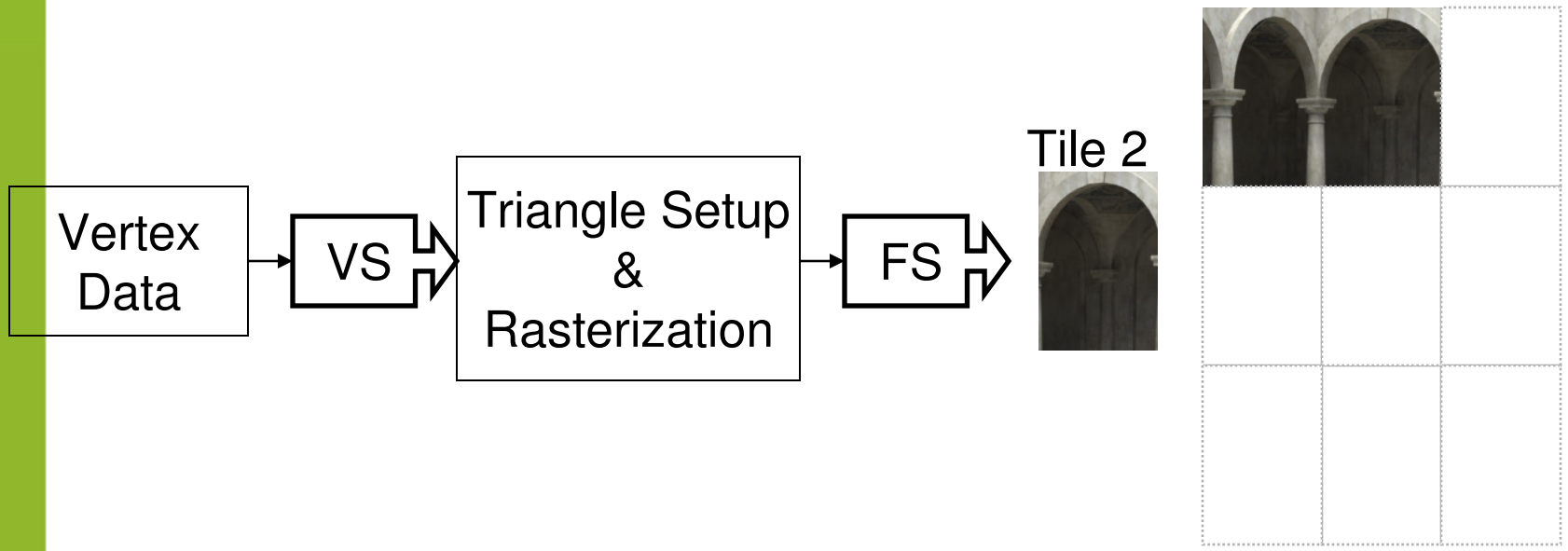
Traditional Graphics Pipeline



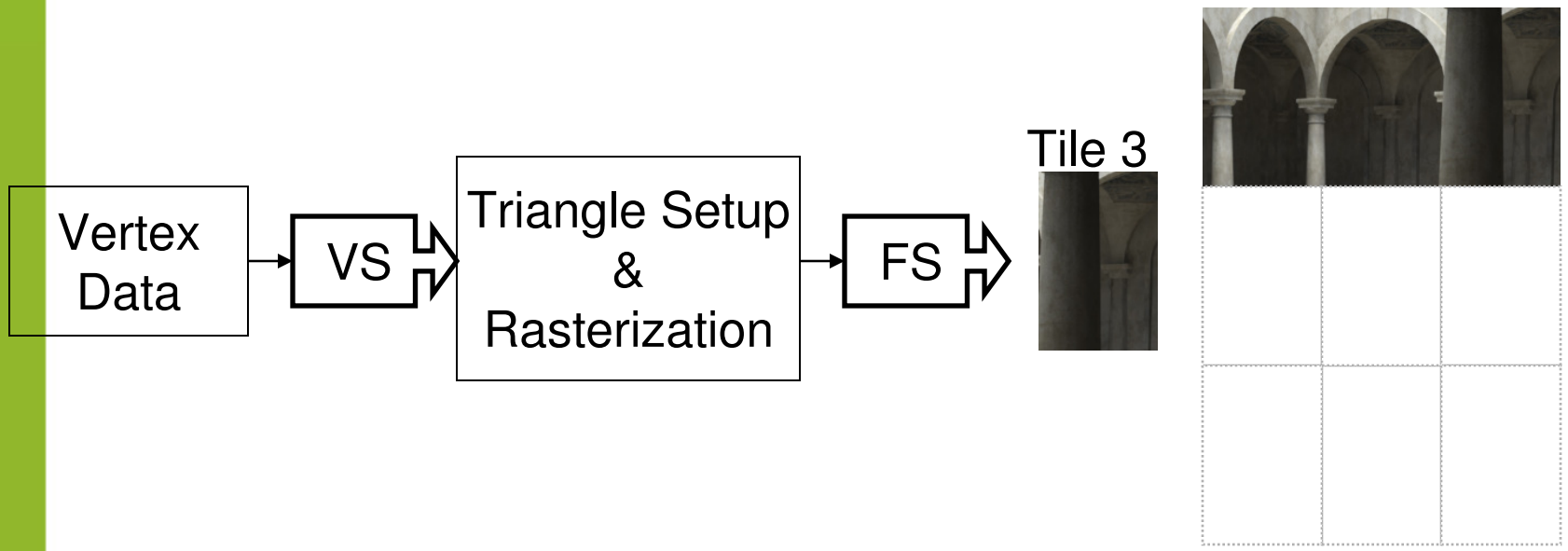
TBR Graphics Pipeline



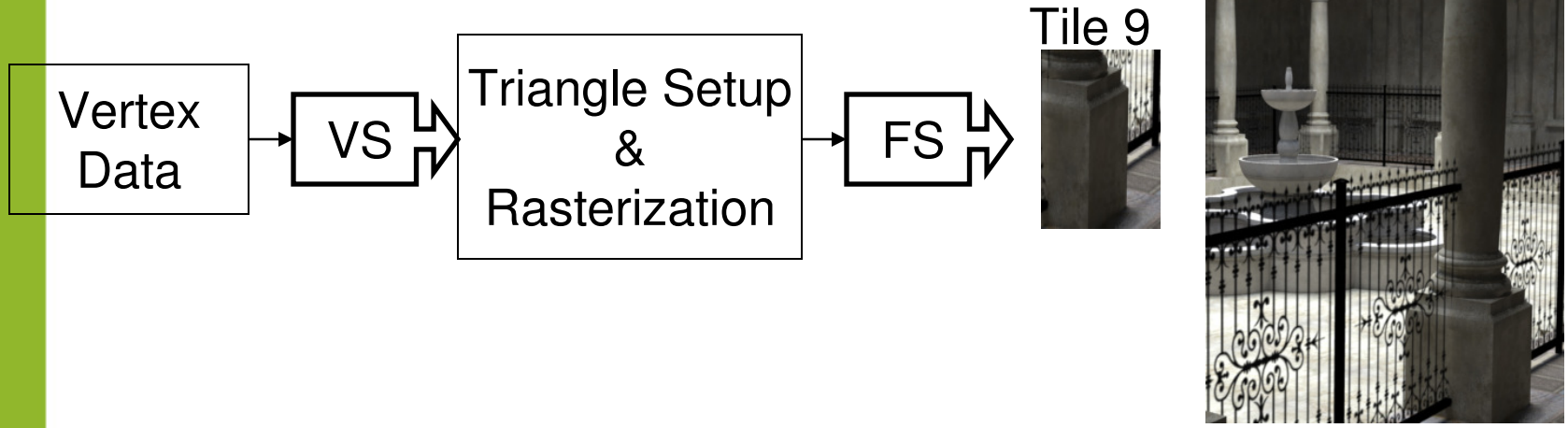
TBR Graphics Pipeline



TBR Graphics Pipeline



TBR Graphics Pipeline



The Agenda

- Introduction to tiling based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

Who Uses TBR?

- Microsoft
  - Talisman
- Imagination Technologies
  - KYRO and KYRO II (Desktop PC)
  - PowerVR CLX2 (Sega Dreamcast)
  - PowerVR MBX (OpenGL ES 1.x)
  - **PowerVR SGX (targets OpenGL ES 2.0)**
- AMD
  - Imageon 2380 (OpenGL ES 1.x)
  - Xenos (Xbox 360)
  - **Z430 and Z460 (targets OpenGL ES 2.0)**

Why is TBR so Popular in Embedded Devices?

- Reduced bus bandwidth
  - Saves power
  - Allows for simpler system designs
  - Desktop PC's brute force approach doesn't work as well in the mobile space
- Lower polygon counts in mobile games are an ideal match for TBR

The Agenda

- Introduction to tiling based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

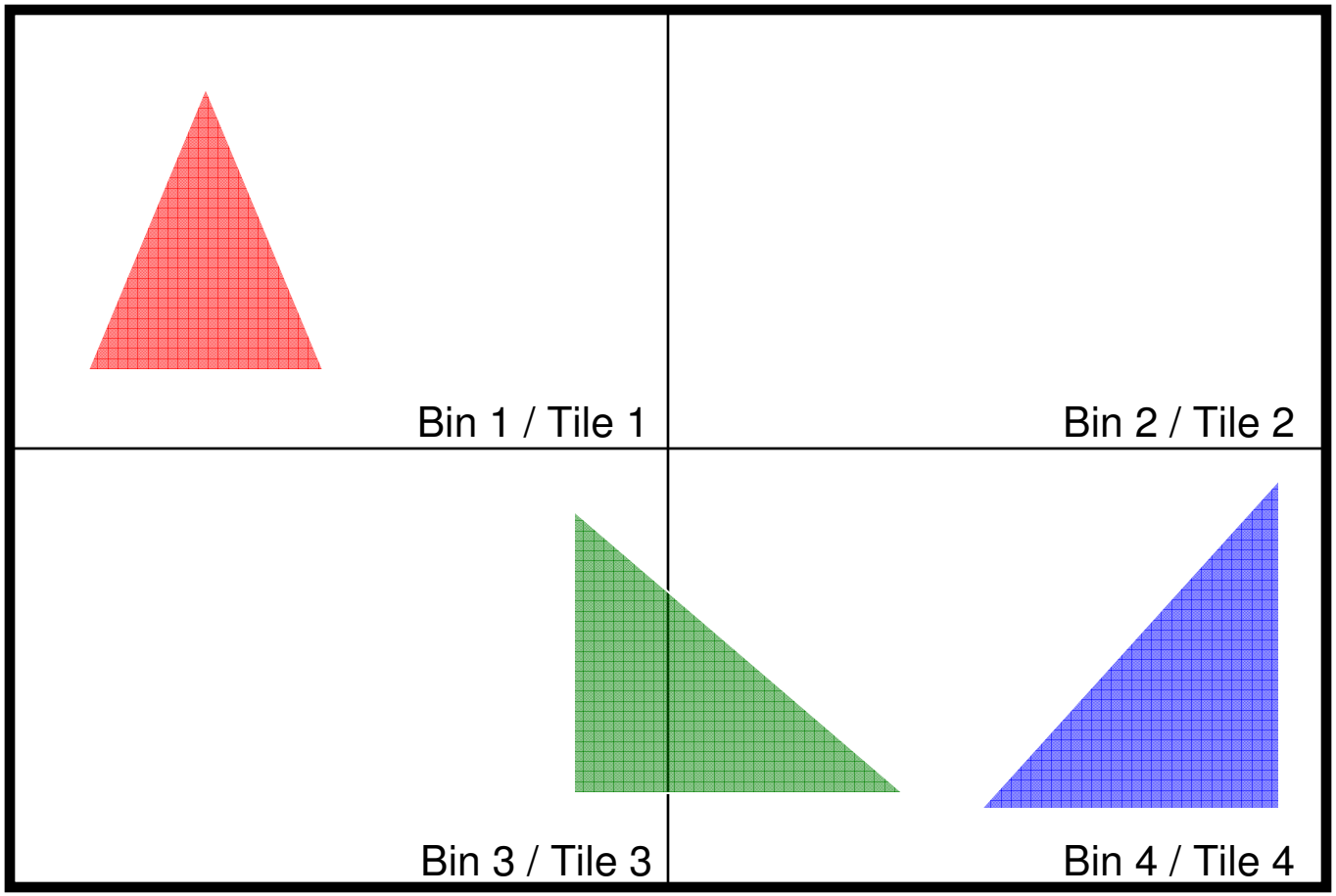
Fast Local Memory

- Tile-based GPUs have a small amount of fast memory on chip
  - Each tile gets rendered here then resolved to the final buffer in system memory
  - Very high bandwidth
  - Very low latency
  - Eliminates need for many caches and complex compression algorithms found on desktop GPUs

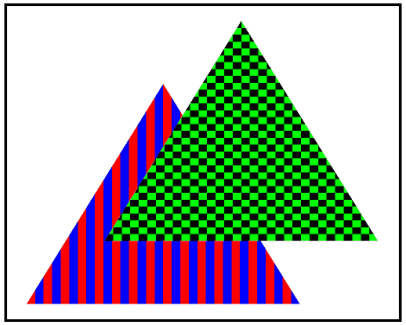
Geometry Binning

- Could just draw the scene to each tile and let the vertices get clipped, but…
- In the real world this costs too much vertex shader performance
- TBR hardware has ways of sorting triangles into bins for each tile
  - Each hardware vendor does this differently
- Don’t forget the driver/hardware has to batch up draw calls

Geometry Binning

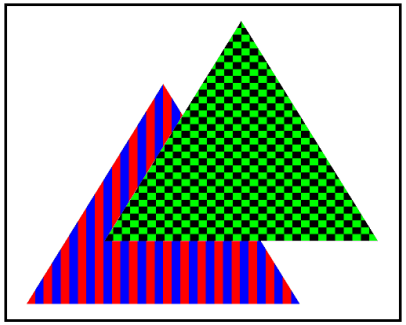


External Bandwidth Usage Example



- Draw two triangles with depth testing
- Each triangle is 100 pixels and there is 50 pixels of overlap
- Each triangle has a single texture fetch
- Depth and color buffers are 32 bits
- Textures are 32 bits (easy math)

External Bandwidth Usage Example



	Traditional Rendering	Tile Based Rendering
Texture Reads	150*4 bytes	150*4 bytes
Depth Reads	200*4 bytes	0 bytes
Depth Writes	150*4 bytes	0 bytes
Color Writes	150*4 bytes	0 bytes
Total Bandwidth	2600 bytes	600 bytes

This is just for the actual rendering TBR has constant bandwidth overhead from resolves

The Agenda

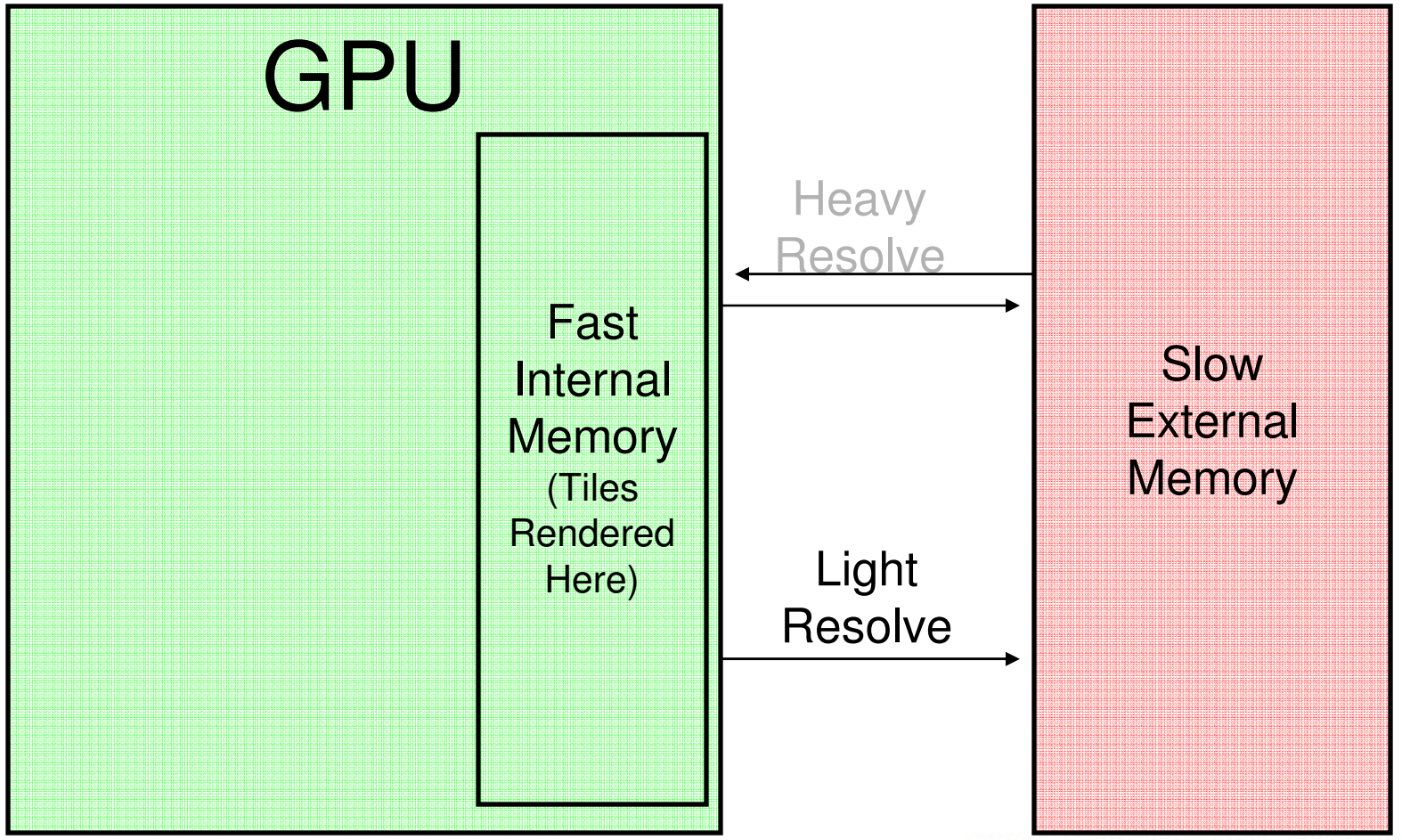
- Introduction to tiling based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

Resolves

- Resolves are the copies between a GPU's fast internal memory and the system's slow external memory
- Light weight resolve
  - Copies from fast internal memory to slow external memory
- Heavy weight resolve
  - Restores a tile with a copy from slow external memory to fast internal memory, and then does a light weight resolve

Heavy Weight Resolves

** This is repeated for each tile **



Resolve Cases

- eglSwapBuffers
  - Light weight resolve
- glBindFramebuffer
  - Light weight resolve if you start drawing with glClear
  - Heavy weight resolve if you don't
- glTexImage2D, glTexSubImage2D, glBufferData, and glBufferSubData
  - Drivers should prevent the resolve
  - Mid-frame calls force driver to create an extra copy of the data
  - Starting a frame with these calls prevents that extra copy

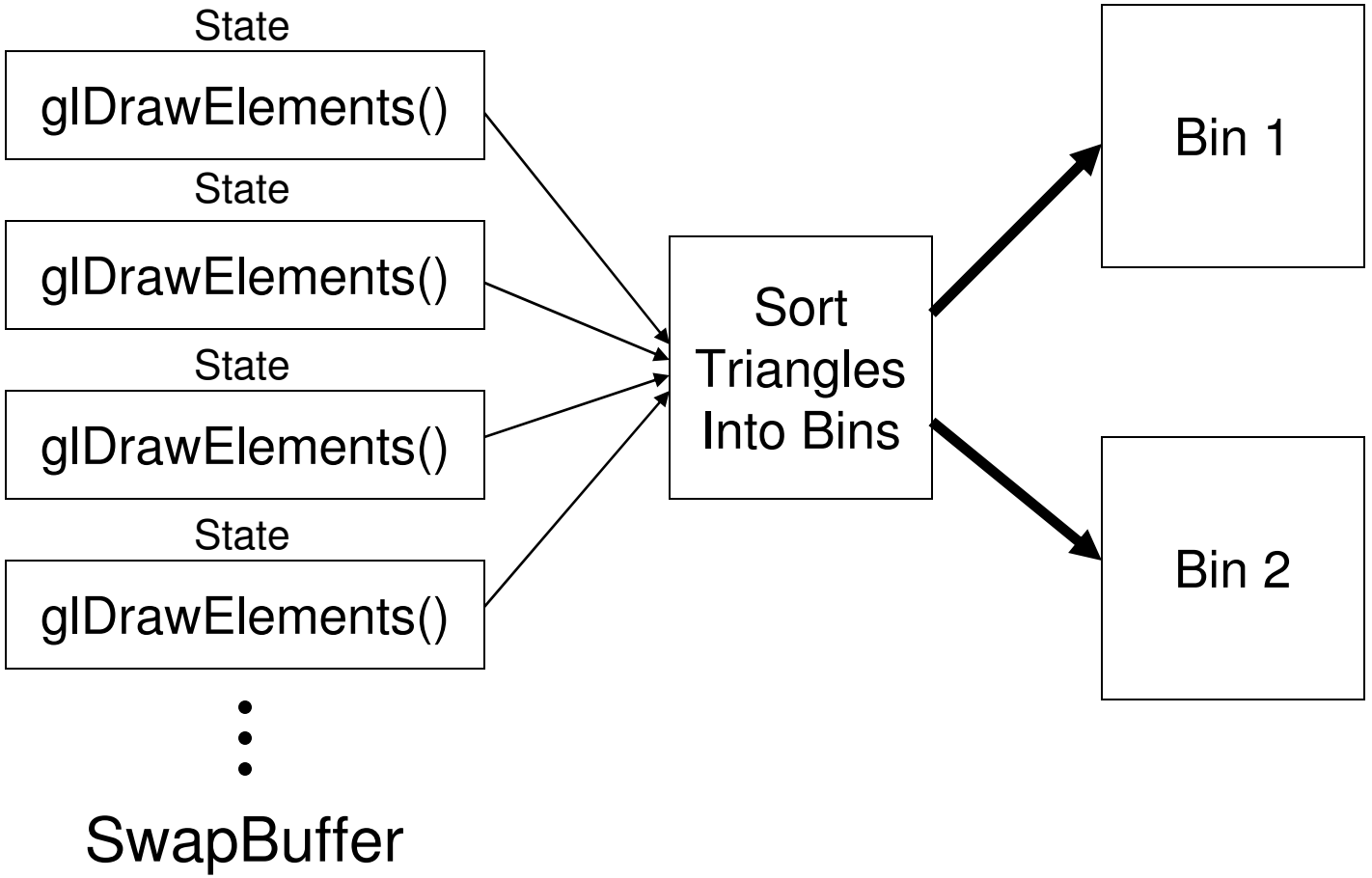
Resolve Cases

- glCopyTexImage2D and glCopyTexSubImage2D
  - Heavy weight resolve
  - OpenGL ES 2.0 has FBOs so use them
- glReadPixels
  - Heavy weight resolve
  - Please don’t use this (especially in the middle of a frame)
- Exceeding triangle or state buffer limits
  - Heavy weight resolve (driver and hardware specific)

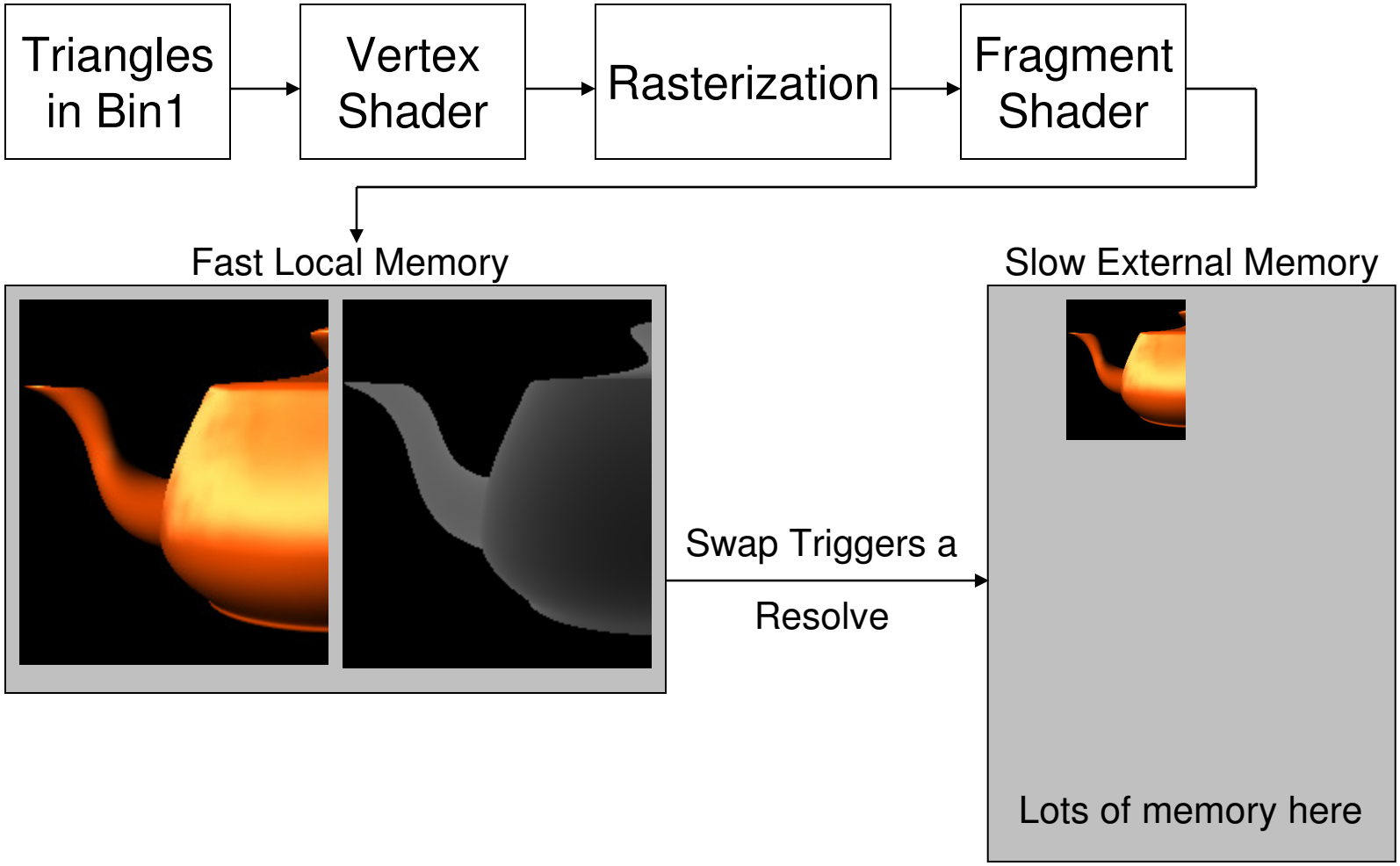
Resolve Friendly Code

```
// Put all glTexImage2D, glTexSubImage2D, glBufferData and
// glBufferSubData commands here

// FBO block (optional - only needed if you are using FBOs)
for (int i = 0; i < numFbos; ++i)
{
    glBindFramebuffer( target[i], framebuffer[i] );
    glClear( GL_COLOR_BUFFER_BIT |
             GL_DEPTH_BUFFER_BIT |
             GL_STENCIL_BUFFER_BIT );
    Draw your scene for each FBO here
}

// If needed put a glClear here (color, depth, stencil)
Draw your scene to your backbuffer here

// If you absolutely need a glReadPixels do it here
eglSwapBuffers( dsp, backbuffer );

...Repeat...
```

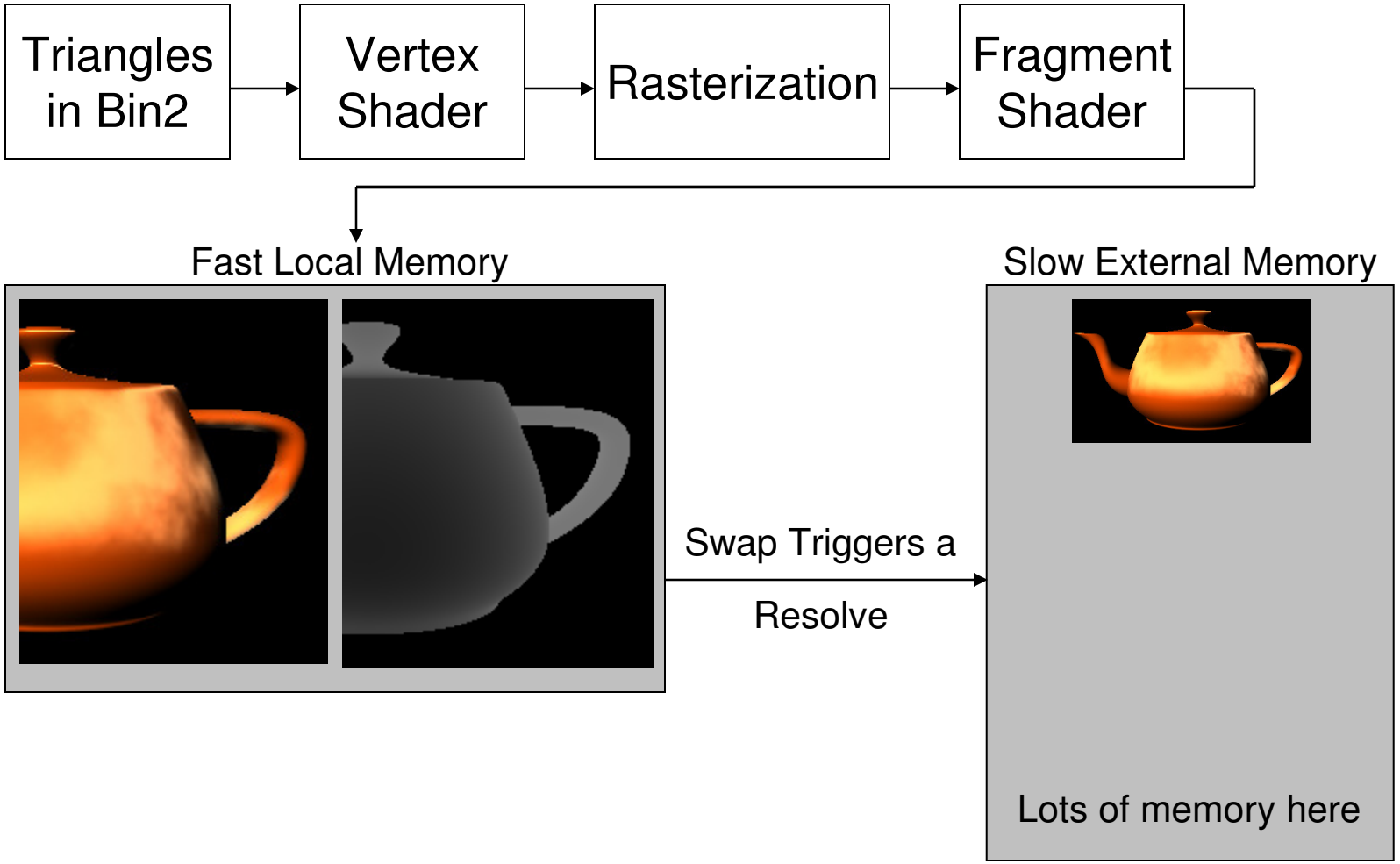
A frame in the life of TBR



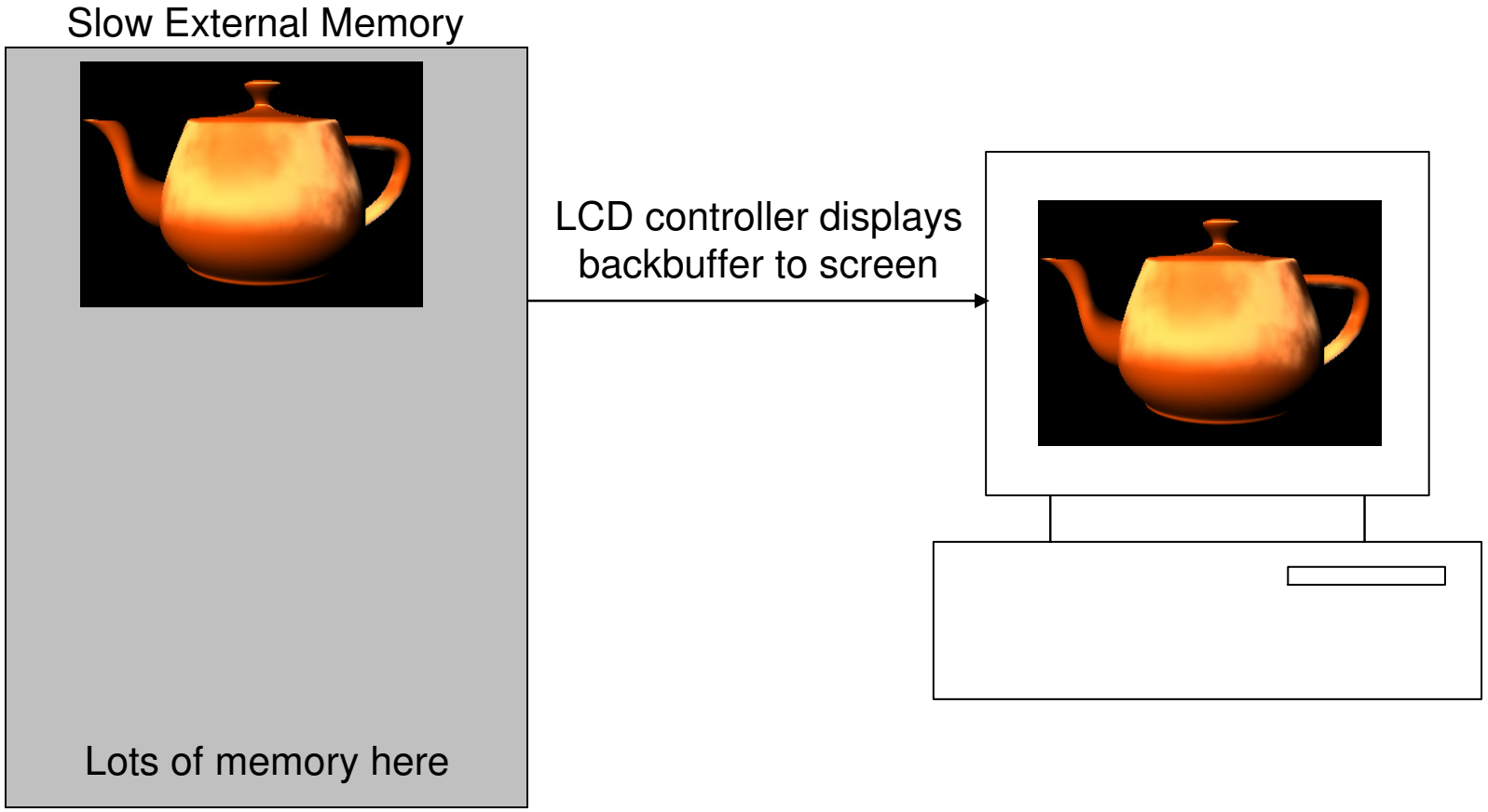
A frame in the life of TBR



A frame in the life of TBR



A frame in the life of TBR



The Agenda

- Introduction to tiling based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

OpenGL ES 2.0 Emulators

- Develop OpenGL ES 2.0 code before hardware is available
- Use the Visual Studio's build environment
- Graphics code should require no changes when porting to real hardware
- Help track down TBR performance bottlenecks

OpenGL ES 2.0 Emulators

- Two OpenGL ES 2.0 emulators are:
  - AMD
    - http://ati.amd.com/developer/tools.html
    - Future Releases will have
      - Performance throttling to simulate real hardware
      - Detailed performance stats to help find bottlenecks
  - Imagination
    - http://www.imgtec.com/PowerVR/insider/toolsSDKs/KhronosOpenGLES2xSGX
- Demo

The Agenda

- Introduction to tiling based rendering
- Tiling is most common in mobile systems
- List of common tiling hardware features
- Resolves
  - Explanation of the different types
  - Optimizing code for resolves
- OpenGL ES 2.0 emulators
- Conclusion

TBR Strengths

- In general TBR excels at bandwidth limited operations
  - Blending
  - Overdraw
  - Multisample AA

The Take Home Message

- Hopefully you now know what TBR is
- Avoid extra resolves
  - Costs power and reduce battery life
  - Costs performance
- Optimizing for TBR usually only takes a few small changes
- OpenGL ES 2.0 Emulators are a good way to start writing efficient code

GameDevelopers Conference Mobile 08

Questions?

Maurice.Ribble@amd.com

devrel@amd.com

CMP