OpenGL 3 Overview

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OpenGL ARB Chair

Agenda

- OpenGL 3.1 announcement and OpenGL 3 overview
  - Barthold Lichtenbelt, NVIDIA
- OpenGL 2 vs OpenGL 3
  - Jeremy Sandmel, OpenGL-next TSG chair
- Blizzard perspective
  - Rob Barris, Blizzard
- TransGaming perspective
  - Gavriel State, TransGaming
- gDEBugger demo
  - Avi Shapira, Graphic Remedy

OpenGL 3

The train has left!

Structure

- Overview of OpenGL 3.0 and GLSL 1.30
- The new deprecation model
- OpenGL 3.1 and GLSL 1.40
- OpenGL and OpenCL
- Future plans
- OpenGL 3 IHV support statements

OpenGL 3.0 and GLSL 1.30

OpenGL 3 – Moving OpenGL forward

- Expose all available hardware features asap
- Keep innovating where it makes sense
- Increase ease of porting from DX9 and DX10 to OpenGL
- Introduce mechanism to remove features
- Introduce mechanism to provide market specific features
- Enable interoperability with compute (OpenCL)
- Become a true superset of OpenGL ES

This is done incrementally, as a series of point releases, schedule driven

OpenGL 3.0 and GLSL 1.30

- Support for latest generations of Programmable Hardware
  - Installed base > 100 Million units
- Announced at Siggraph 2008
- Drivers now shipping from AMD, NVIDIA and S3 Graphics
  - gDEBugger support also available
- Introduced a ton of new features
- No removal of any feature, fully backwards compatible
- Full interoperability with OpenCL
  - Access to compute
- Collaboration among hardware vendors and software vendors
  - Solving real needs
- Cross platform
  - Windows XP and Vista, Linux, Mac OS, ...

OpenGL 3.0 new features

- Forward-looking context
- Greater VBO flexibility
- FBO and related extensions
  - EXT_framebuffer_object, EXT_framebuffer_blit, EXT_framebuffer_multisample, EXT_packed_depth_stencil
- Conditional rendering
- Transform feedback
- Floating point internal formats for textures and renderbuffers
- Half-float (16-bit) vertex and pixel data formats
- One and two-channel (R and RG) internal formats for textures and renderbuffers
- RGTC internal compressed texture formats, packed float and texture shared exponent
- sRGB framebuffer support

GLSL 1.30 new features

- Native integer support
  - bitwise operators, texture return values, uniforms, shader input/outputs
- Expanded texturing support
  - Size queries, offsets, explicit LOD and derivative control, texture arrays, integer support
- Switch statements
- Several new built-in functions
  - Hyperbolic trig functions
  - trunc(), round(), roundEven(), isnan(), isinf(), modf()
  - Integer related: sign(), min/max(), abs(), ….
- Pre-processor token pasting (##)
- User-defined fragment outputs
- Non-perspective interpolation of varying variables
- gl_VertexID vertex shader input
- Follows the same deprecation model as the API

OpenGL 3.0 based on:

- EXT_gpu_shader4
- NV_conditional_render
- ARB_color_buffer_float
- NV_depth_buffer_float
- ARB_texture_float
- EXT_packed_float
- EXT_texture_shared_exponent
- NV_half_float
- ARB_half_float_pixel
- EXT_framebuffer_object
- EXT_framebuffer_multisample
- EXT_framebuffer_blit
- EXT_texture_integer
- EXT_texture_array
- EXT_packed_depth_stencil
- EXT_draw_buffers2
- EXT_texture_compression_rgtc
- EXT_transform_feedback
- APPLE_vertex_array_object
- EXT_framebuffer_sRGB
- APPLE_flush_buffer_range
- ARB_texture_RG

Extensions for OpenGL 3.0

Feature	Extension for OpenGL 3.0
Platform extension support for managing OpenGL 3.0 contexts	{WGL|GLX}_ARB_create_context
Geometry shaders to modify vertices and/or generate new vertices and primitives	ARB_geometry_shader4
Large 1D table lookups for GLSL	ARB_texture_buffer_object
Instanced primitive rendering for OpenGL 3.0 capable hardware	ARB_draw_instanced

Extensions for OpenGL 2.x

Feature from OpenGL 3.0	Extension for OpenGL 2.x
All framebuffer object functionality	ARB_framebuffer_object
16-bit floating point vertex formats	ARB_half_float_vertex
sRGB color space rendering	ARB_framebuffer_sRGB
More efficient buffer mapping	ARB_map_buffer_range
1 and 2 component texture compression	ARB_texture_compression_rgtc
Efficient vertex array state management	ARB_vertex_array_object
1 and 2 component render-to-texture	ARB_texture_rg
Vertex array instancing for OpenGL 2.x capable hardware	ARB_instanced_arrays

The Deprecation Model

Removing features

- OpenGL has never removed features
  - Commitment to backwards compatibility is one of OpenGL's strengths
  - After 15+ years, defining new features to work with old features becomes increasingly difficult
- OpenGL 3.0 did not remove any features
- OpenGL 3.0 did mark certain features as deprecated
  - Redundant, Legacy and obsolete features
  - Parts of OpenGL unlikely to be accelerated
- Future OpenGL revisions will remove these deprecated features
  - Guidance to developers to prepare for future revisions
  - Plan to remove these features sooner, rather than later.

Deprecated features

- Fixed-function vertex and fragment processing
- Color-index mode
- Display lists, and Selection and Feedback modes
- GLSL 1.10 and 1.20
- Begin/End based rendering
- Application-generated object names
- Quads and polygon primitives
- Polygon and Line Stipple
- Pixel transfer modes
- Bitmaps, DrawPixels, PixelZoom
- *and quite a few others*...
  - See Appendix E of OpenGL 3.0 specification for the list

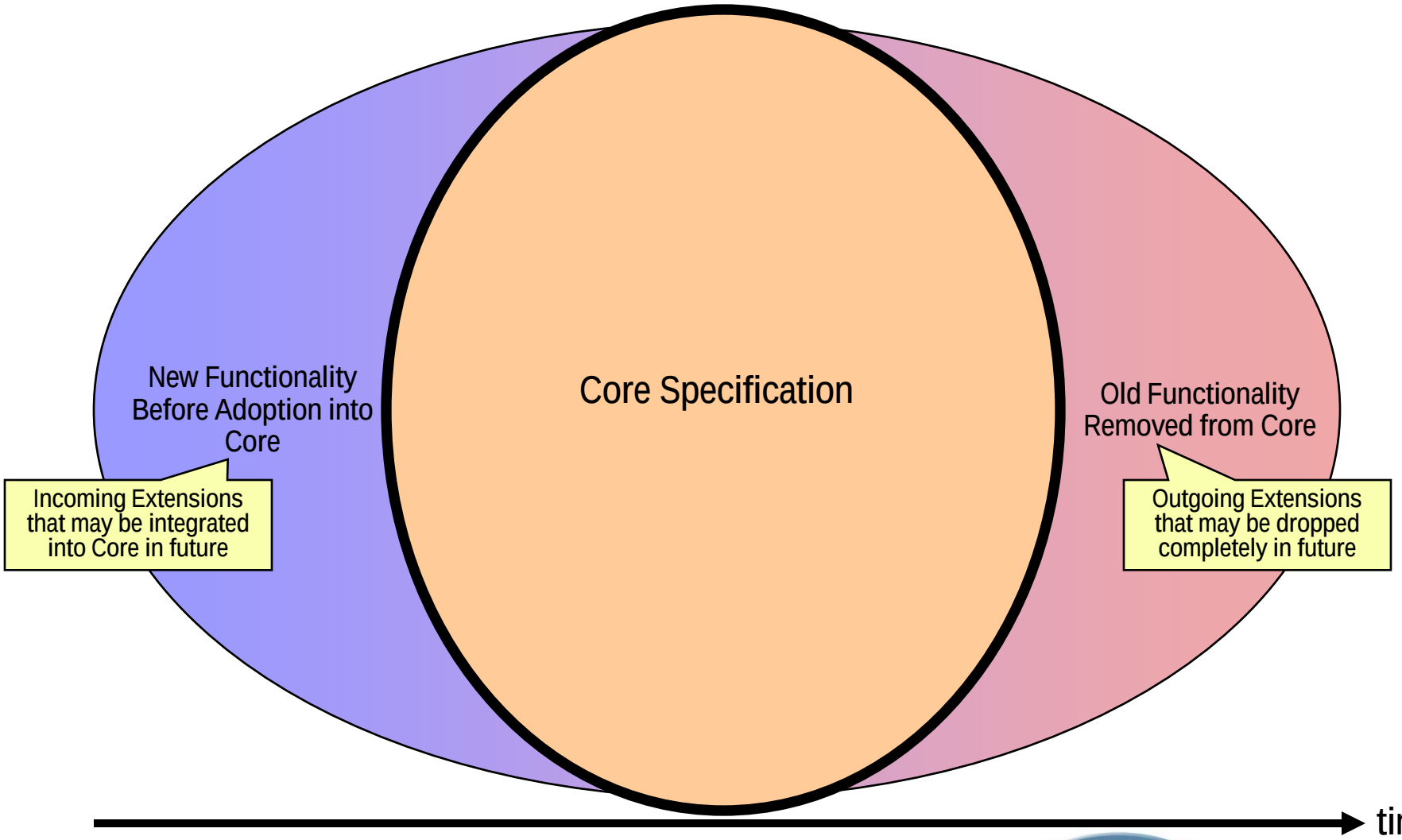
Deprecation mechanism

- Step 1 Core feature
  - In core, fully supported. **Will** be in the next API version
- Step 2 Core (Deprecated feature)
  - In core, marked as deprecated
  - **May** be fully or partly removed in a later version
  - New features need not define interactions with deprecated ones
- Step 3 ARB approved Extension
  - **Removed** from core -> an ARB extension (no suffix)
  - Extension spec identifies the removed functionality
  - Vendors may support the extension if markets require it
- Step 4 Removed from ARB extension list
  - Could be an EXT or vendor extension, if vendor markets still require it (still no suffixes required)

Deprecation mechanism

- Features will be deprecated for at least one spec release (step 2) before being removed
- Extension Path: **`Vendor/EXT->ARB->Core`**
  - With possible API / functionality changes as we learn from experience
- Deprecation Path: **`Core->ARB->EXT/Vendor`**
  - No API or functionality changes

Feature Evolution Model - Deprecation



OpenGL 3.1 and GLSL 1.40

Released 3/24/09

Announcing OpenGL 3.1

- More Texturing
  - Texture Buffer Objects
  - SNORM Texture format support
  - Rectangle Textures
- Additional Buffer management
  - Copy data between buffers
  - Uniform buffer objects
- Better Vertex Processing
  - Primitive Restart (NV_primitive_restart)
  - Instancing (ARB_draw_instanced)
- Removal of features
  - Everything on the deprecated list in OpenGL 3.0
- ARB_compatibility extension
  - Optional. Encapsulates removed functionality
- New Programmability
  - GLSL 1.40
  - Uniform Buffer Objects

Announcing GLSL 1.40

- Uniform blocks to be backed by buffer objects
  - Major new feature
- Texture buffers
- **`gl_InstanceID`** for instance drawing
- Don't require writing to **`gl_Position`**
- Rectangular textures

New Extensions for OpenGL 2.x

Feature from OpenGL 3.0/3.1	Extension for OpenGL 2.x
All framebuffer object functionality	ARB_framebuffer_object
16-bit floating point vertex formats	ARB_half_float_vertex
sRGB color space rendering	ARB_framebuffer_sRGB
More efficient buffer mapping	ARB_map_buffer_range
1 and 2 component texture compression	ARB_texture_compression_rgtc
Efficient vertex array state management	ARB_vertex_array_object
1 and 2 component render-to-texture	ARB_texture_rg
Vertex array instancing for OpenGL 2.x capable hardware	ARB_instanced_arrays
Store uniform values in buffer objects	ARB_uniform_buffer
Copy data between buffer objects	ARB_copy_buffer

OpenGL 3.1 based on

- ARB_copy_buffer
- NV_primitive_restart
- ARB_draw_instanced
- ARB_texture_buffer_object
- ARB_texture_rectangle
- ARB_uniform_buffer_object

Uniform Buffer Objects

- Introduction of uniform blocks
  - Group of uniforms declared in a shader
- Storage for values in uniform blocks is provide by a buffer object
- Defines standard (portable) and optimized layouts
  - Portable across OpenGL implementations
  - Portable across program objects and shader stages
  - Or fully optimized, non-portable
- Uniform data is loaded with existing buffer object API
- A buffer object is bound to an element of an array of uniform block binding points
  - This is context state
- A (program, uniform block) pair is associated with an element in the same array

Advantages

- Sharing of uniform data between program objects and program stages
- Rapid switching between sets of uniform data
  - Buffer objects stored on the server
  - Eliminate calling glUniform* many times over
- Rapid updates of uniform data
  - Using the existing buffer object commands. BufferData(), MapBufferRange() etc.
- Can store arbitrarily complex structures of data
  - Not limited to arrays of uniforms anymore
- Standard layout of data in memory, even across OpenGL vendors
  - Determined by a set of packing rules. Inspection of GLSL source code conveys layout
- Can store large amounts of data
  - Storage provided by a buffer object

Uniform buffer object example

```
#extension GL_ARB_uniform_buffer_object : enable

// Define a uniform block, using std140 layout
layout(std140) uniform colors0 {
    float DiffuseCool;
    float DiffuseWarm;
    vec3  SurfaceColor;
    vec3  WarmColor;
    vec3  CoolColor;
};


 void main (void)
{
    vec3 kcool = min(CoolColor + DiffuseCool * SurfaceColor, 1.0);
     ...
     gl_FragColor = ...
}
```

Program initialization (1/2)

```
//There's only one uniform block, the 'colors0' uniform block.
uniformBlockIndex = glGetUniformBlockIndex(prog_id,
                                           "colors0");

//associate the uniform block to binding point 0
glUniformBlockBinding(prog_id, uniformBlockIndex, 0);

//Get the uniform block's size
glGetActiveUniformBlockiv(prog_id, uniformBlockIndex,
                          GL_UNIFORM_BLOCK_DATA_SIZE_ARB,
                          &uniformBlockSize);
```

Program initialization (2/2)

```
//SurfaceColor might change, so we'll query its offset/size.
const char *name = "SurfaceColor";

//First, get the index for the uniform
glGetUniformIndices(prog_id, 1, &name, &index);

//Use the index to query offset and size
glGetActiveUniformsiv(prog_id, 1, &index,
                      GL_UNIFORM_OFFSET_ARB, &offset);
glGetActiveUniformsiv(prog_id, 1, &index,
                      GL_UNIFORM_SIZE_ARB, &singleSize);

//Because this is std140 layout, we know the answer already
assert(offset == 16 && singleSize == 12);
```

Buffer initialization

```
//Create UBO
glBindBuffer(GL_UNIFORM_BUFFER_ARB, buffer_id);

//We can use BufferData to upload our data to the shader,
//since we know it's in the std140 layout
glBufferData(GL_UNIFORM_BUFFER_ARB, uniformBlockSize, NULL,
             GL_DYNAMIC_DRAW);
```

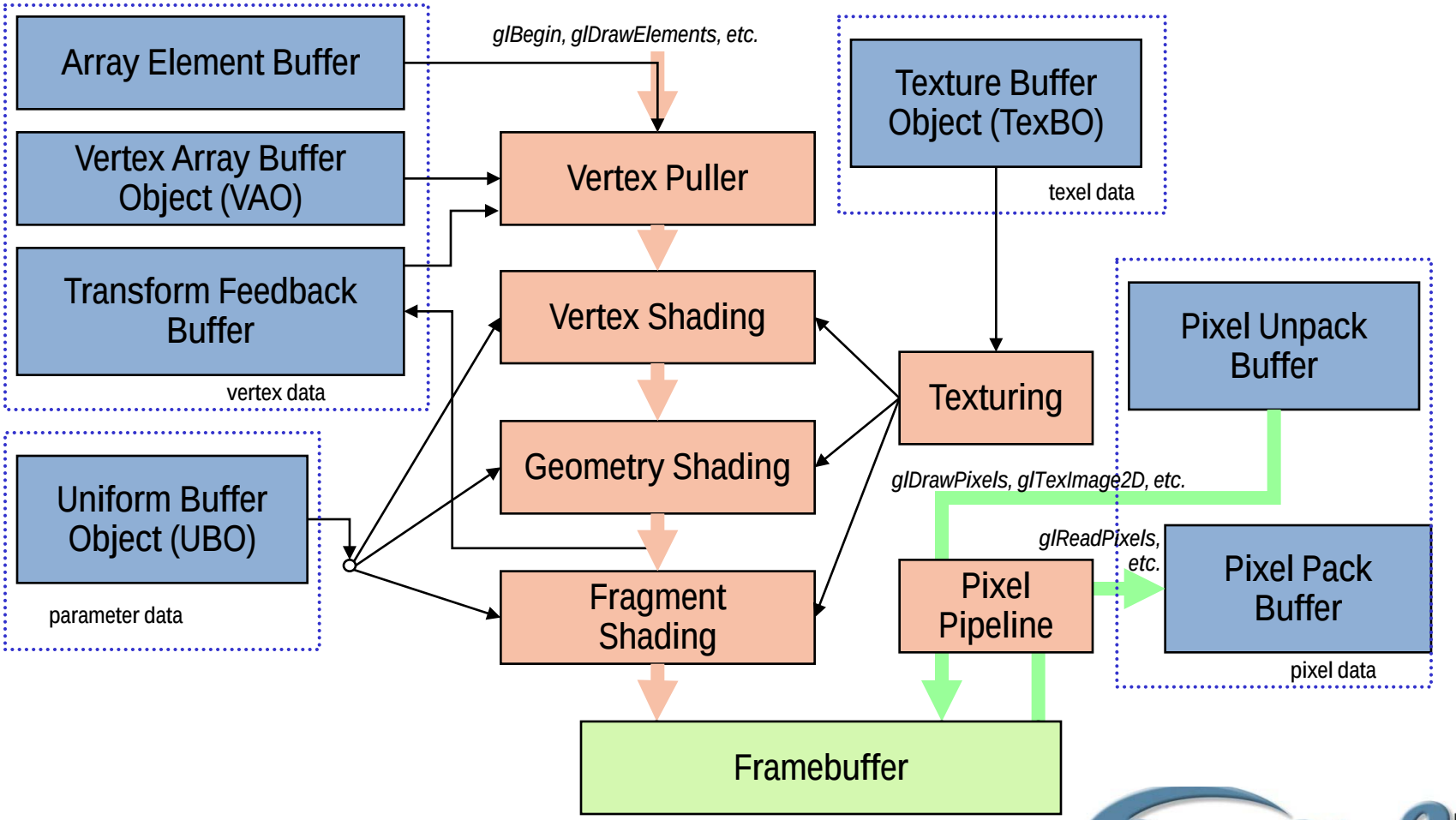
Draw time

```
foreach (object) {
    // Set state
    // Bind vertex buffers

    // Bind constants to UBO binding point 0
    glBindBufferBase(GL_UNIFORM_BUFFER_ARB, 0, buffer_id);

    if (surfacecolor has changed) {
        glBufferSubData(GL_UNIFORM_BUFFER_ARB, offset,
                        singleSize, &newcolor);
    }
    Draw();
}
```

OpenGL 3 Modern Buffer-centric Processing Model



OpenGL and Compute

OpenGL and OpenCL synergy

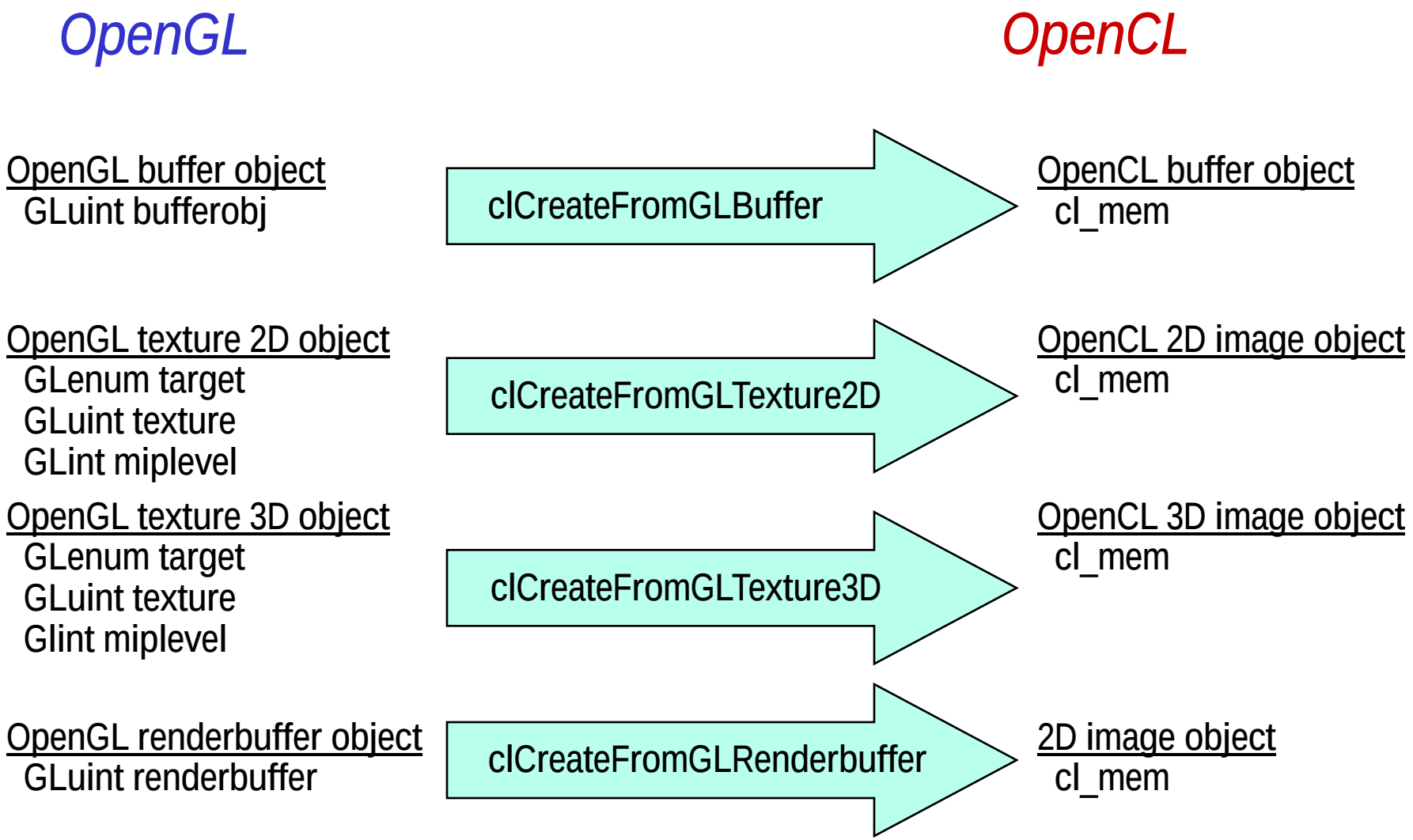
- Complimentary capabilities
  - OpenGL 3.x = state-of-the-art, cross-platform graphics
  - OpenCL 1.0 = state-of-the-art, cross-platform compute
- Computation & Graphics should work together
  - Most natural way to intuit compute results is with graphics
  - When Compute is done on a GPU, there's no need to "copy" the data to see it visualized

=> Use OpenCL for compute!

OpenGL and OpenCL interop

- Interop – the ability to efficiently transfer buffers or textures between OpenGL and OpenCL
- Enables application to use the API that makes most sense for their problem domain
  - No square peg in a round hole gymnastics
- Works on single GPU and multi-GPU systems

Four Kinds of Shared Objects



What we said at Siggraph 2008

- Schedule driven 
- ARB extensions are candidates for folding into a future core
  - ARB_draw_instanced 
  - ARB_geometry_shader
  - ARB_texture_buffer_object 
- Backing uniform variables with buffer objects 
- #include mechanism for GLSL
- Attribute index offsets
- Remove deprecated features 
- Profiles 
- Object model improvements
- Other functionality you need? 

Future versions

- ARB just started discussion on the next version - release likely within a year
- Close look at what remains to be done to increase ease of DX portability
- ARB extensions: Geometry shaders and copy buffer
- Finish making GLSL a true superset of ES
- Using program objects without linking
- Direct State Access
- Sampler objects - Splitting a texture object into image and sampler object
- Support for loading shader binaries
- Fences
- User specified UBO packing
- Explicit MSAA control
- Cube map arrays, MRT blending, Tesselation, Programmable blending

OpenGL 3.1 Specification Download

http://www.opengl.org/registry

Three new specs approved and available today

1) OpenGL 3.1 specification

2) OpenGL 3.1 + ARB_compatibility extension

3) GLSL 1.40 specification

OpenGL 3.1 IHV Statements

AMD and OpenGL 3.0 / OpenGL 3.1

- AMD already ships OpenGL 3.0 today
  - Full context
  - Forward compatible context
  - Support for Radeon and FirePro products
- AMD will add support for OpenGL 3.1 in the next few months
- AMD will support for ARB_compatibility extension which enables existing application to more easily use the latest features

- Contact AMD for details: pierre.boudier@amd.com

Intel on OpenGL 3.1

- “Intel is excited about OpenGL 3.1, the continuing evolution of OpenGL, and our future product support of OpenGL 3.x”

NVIDIA on OpenGL 3.0 / 3.1

- Have been shipping OpenGL 3.0 drivers since Siggraph 2008
- Announcing *immediate* availability of OpenGL 3.1 beta drivers
  - On both Windows and Linux
- OpenGL 3.1 drivers DO support the ARB_compatibility extension

- Download and release notes at
  http://developer.nvidia.com/object/opengl_3_driver.html

Trivia Questions

- How good is your knowledge of OpenGL and GLSL?