Shader Buffers

Uniform & Shader Storage Buffer Objects

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6 February 2020

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Uniform Buffer Objects

Uniform Buffer Objects are used to make more compact and efficient the uploading of uniforms to the Shaders.

Instead of passing one variable at a time, developers can pass **multiple variables at once**. It is particularly useful when a group of data represent different characteristics of a same object/feature of the environment.

Furthermore, some values (as View and Projection Matrices) are used in multiple shaders; updating the values of a UBO, OpenGL automatically **updates all the shaders**, to which the UBO is bound.

Uniform Interface Blocks

In the **shader**, the buffer object is defined as an **Interface Block**. It's syntax is analogous to a `struct` in C:

every Block has *at least* a **layout specifier**, a **Block Name** (seen by OpenGL code), some **members** (the stored data) and (optionally) an **Instance Name** (seen by GLSL code); arrays of Blocks con be defined.

Simple

```
layout (std140) uniform CameraBlock {
  mat4 ViewMatrix;
  mat4 ProjectionMatrix;
};
...
pass_Position = ViewMatrix * ModelMatrix * ...
```

Instance Name

```
layout (std140) uniform CameraBlock {
  mat4 ViewMatrix;
  mat4 ProjectionMatrix;
} blockCam;
...
pass_Position = blockCam.ViewMatrix * blockCam.ModelMatrix * ...
```

Block Array

```
layout (std140) uniform CameraBlock {
  mat4 ViewMatrix;
  mat4 ProjectionMatrix;
} blockCam[3];
...
pass_Position = blockCam[1].ViewMatrix * blockCam[1].ModelMatrix
```

Interface Block (GLSL)

Fig. 1: Uniform Interface Blocks Examples

UBO Bindings

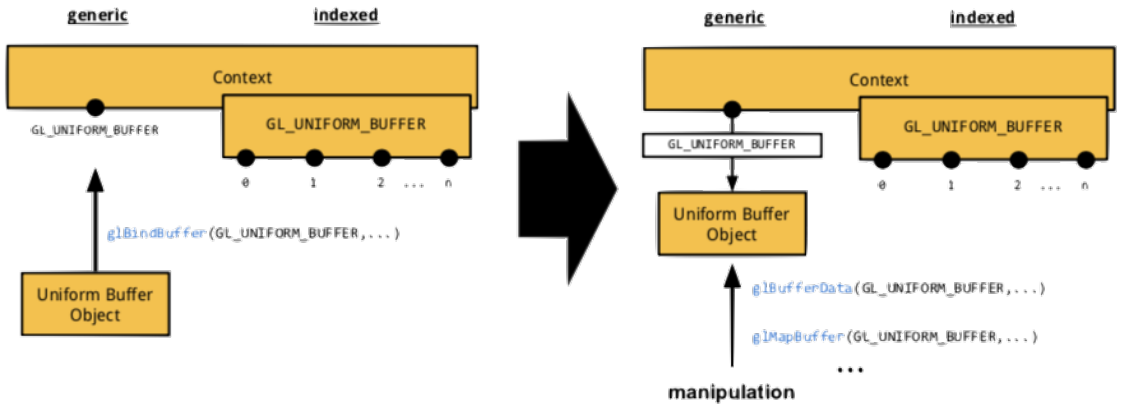

Fig. 2: Generic UBO Binding

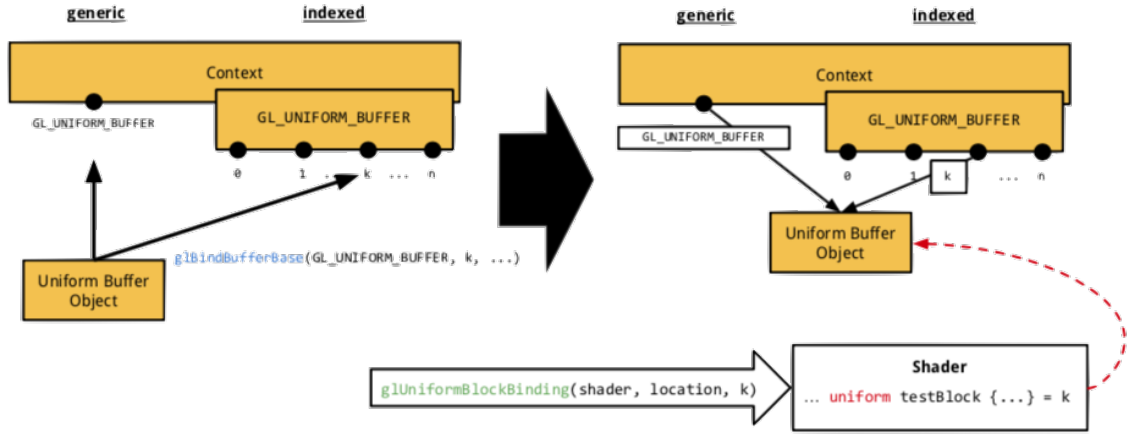

Fig. 3: Indexed UBO Binding

Buffer Block Memory Layouts

There are 4 alternatives Memory Layouts:

- **packed**: performance–oriented and implementation–determined, the layout is determined by the internals and the actual exchanged data may vary.
- **shared**: loosened version of `packed`; no variation on the exchanged data format, a certain type of Block has the same layout in different programs.
- **std140**: fixed layout at declaration time, wastes space introducing paddings to 16–bits multiples.
- **std430**: similar to `std140`, but without the additional paddings (to be used **only** with Shader Storage Blocks).

UBO Usage

Create Uniform Buffer Object

```
glGenBuffers(1, &ubo_handle)
glBindBufferBase(GL_UNIFORM_BUFFER, buff_idx, ubo_handle)
glBufferData(GL_UNIFORM_BUFFER, size, nullptr, usage)
```

Bind UBO to shader Interface Block

```
GLuint loc=glGetUniformBlockIndex(pr_handle, ``BlkName'')
glUniformBlockBinding(pr_handle, loc, buff_idx)
```

Update Buffer Data (when necessary)

```
glBindBuffer(GL_UNIFORM_BUFFER, ubo_handle)
void* buff_ptr=glMapBuffer(GL_UNIFORM_BUFFER, GL_WRITE_ONLY)
std::memcpy(data_ptr, buffer_ptr, buffer_size)
glUnmapBuffer(GL_UNIFORM_BUFFER)
```

Shader Storage Buffer Object

They are similar to UBO, but there are some differences:

- SSBOs can be larger (up to 128MB instead of 16KB).
- SSBOs are writable from the shaders (UBO are not).
- SSBOs can have variable size and so they can store arrays of arbitrary length.

Because they provide more flexibility, they are less efficient than UBOs.

They are supported **only by OpenGL v4.3**.

Shader Storage Interface Blocks

SSIBs declaration has the same structure of UIBs'.

However, the storage qualifier here **must** be `buffer` instead of `uniform`, the accepted layouts are **only std140 and std430** and it is possible to use arrays of arbitrary size (preferably located as last data).

The array size can be accessed with the GLSL command `myArray.lenght()`.

Constant Size

```
const uint NUM_LIGHTS = 10;
layout (std430) buffer LightBlock {
  vec4 ViewPosition;
  vec4 LightPositions[NUM_LIGHTS];
};
...
for (uint i = 0; i < LightPositions.length(); ++i) {
    ...
}
```

Dynamic Size

```
layout (std430) buffer LightBlock {
  vec4 ViewPosition;
  vec4 LightPositions[];
};
...
for (uint i = 0; i < LightPositions.length(); ++i) {
    ...
}
```

Fig. 4: Shader Storage Interface Blocks Examples

SSBO Usage

Create Shader Storage Buffer Object

```
glGenBuffers(1, &ssbo_handle)
glBindBufferRange(GL_SHADER_STORAGE_BUFFER, buff_idx,
ssbo_handle, offset, used_data_size)
glBufferData(GL_SHADER_STORAGE_BUFFER, size, nullptr,
usage)
```

Bind UBO to shader Interface Block

```
GLuint loc=glGetProgramResourceIndex(pr_handle,
GL_SHADER_STORAGE_BLOCK, ‘‘BlkName’’)
glShaderStorageBlockBinding(pr_handle, loc, buff_idx)
```

Update Buffer Data (when necessary)

```
glBindBuffer(GL_SHADER_STORAGE_BUFFER, ssbo_handle)
void* buff_ptr=glMapBuffer(GL_SHADER_STORAGE_BUFFER,
GL_WRITE_ONLY)
std::memcpy(data_ptr, buffer_ptr, buffer_size)
glUnmapBuffer(GL_SHADER_STORAGE_BUFFER)
```

Thanks for the Attention and Good Luck for the Exam!