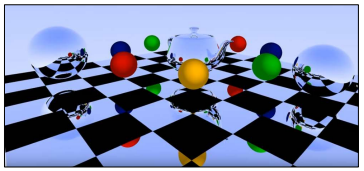
1

Firing Rays

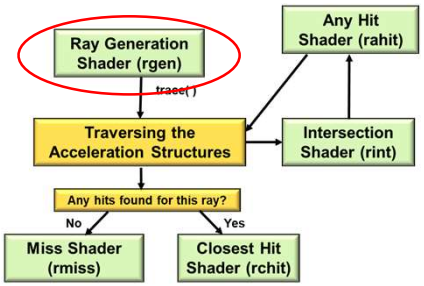
Oregon State University
Mike Bailey
mjb@cs.oregonstate.edu



1

2

Firing Rays First Takes Place in the Ray Generation Shader



New shader stage names:

```
VK_SHADER_STAGE_RAYGEN_BIT
VK_SHADER_STAGE_ANY_HIT_BIT
VK_SHADER_STAGE_CLOSEST_HIT_BIT
VK_SHADER_STAGE_MISS_BIT
VK_SHADER_STAGE_INTERSECTION_BIT
VK_SHADER_STAGE_CALLABLE_BIT
```

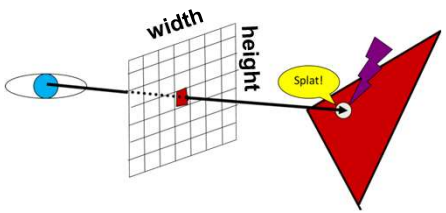

2

3

The Trigger comes from the Command Buffer: vlCmdBindPipeline( ) and vkCmdTraceRays( )

```
vkCmdBindPipeline( CommandBuffer, VK_PIPELINE_BIND_POINT_RAYTRACING, RayTracePipeline );

vkCmdTraceRays(
                CommandBuffer,
                raygenShaderBindingTable
                missShaderBindingTable,
                hitShaderBindingTable,
                callableShaderBindingTable,
                width,
                height,
                1               // depth
);
```



3

4

What Is a Shader Binding Table (SBT)?

When a ray hits a piece of geometry in the scene, the system must figure out what set of shaders need to be called to handle intersections and shading calculations..

This set of shaders is called the **Shader Binding Table** (SBT).

4

That causes the Raygen Shaders to make Numerous Calls to traceRay( )

5

```
traceRay(
        TopLevelAccelerationStructure,
        gl_RayFlagsOpaque,      // ray flags
        0xff                    // the culling mask
        sbtOffset,              // used to lookup the hit group in the SBT
        sbtStride,              // used to lookup the hit group in the SBT
        missIndex,              // which miss shader to call in the shader group
        eyePosition,            // the vec3 ray origin
        tmin,                   // minimum t to allow for an intersection
        rayDir,                 // the ray direction
        tmax,                   // maximum t to allow for an intersection
        0                       // location number holding the payload
);
```

```
layout( location=0, rayPayLoad vec4 payload;        // color
```

```
imageStore( imageIndex, ivec2(gl_LaunchID),  payload );
```

Oregon State University
Computer Graphics

mjb – March 5, 2023

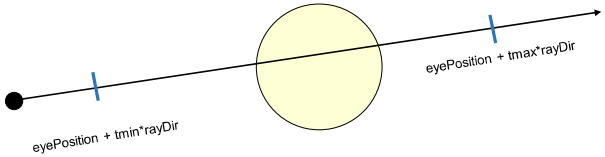
5

The Ray that Gets Fired

6

```
traceRay(
        TopLevelAccelerationStructure,
        gl_RayFlagsOpaque,      // ray flags
        0xff                    // the culling mask
        sbtOffset,              // used to lookup the hit group in the SBT
        sbtStride,              // used to lookup the hit group in the SBT
        missIndex,              // which miss shader to call in the shader group
        eyePosition,            // the vec3 ray origin
        tmin,                   // minimum t to allow for an intersection
        rayDir,                 // the ray direction
        tmax,                   // maximum t to allow for an intersection
        0                       // location number holding the payload
);
```

```
float tmin =     0.01;
float tmax = 1000.;
vec3 rayDir = compute_ray_dir( gl_LaunchID, gl_LaunchSize );
```



Oregon State University
Computer Graphics

mjb – March 5, 2023

6

Computing the Ray Direction

7

```
mat4 inverseModelViewProjection = inverse( gl_ModelViewProjectionMatrix );
```

```
vec3
RayDirection( uvec3 launchID, uvec3 launchSize )
{
        float x = -1.  +  ( 2. * float(launchID.x) + 0.5 ) / float(launchSize.x);     // [-1.,+1.]
        float y = -1.  +  ( 2. * float(launchID.y) + 0.5 ) / float(launchSize.y);     // [-1.,+1.]
        y = -y;
        vec4 ecDirecton = inverseModelViewProjection * vec4( x, y, 0., 1. );
        return normalize( ecDirecton.xyz  );
}
```

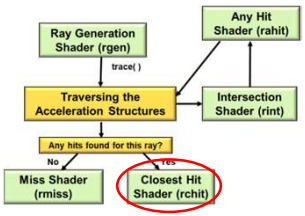
Oregon State University
Computer Graphics

mjb – March 5, 2023

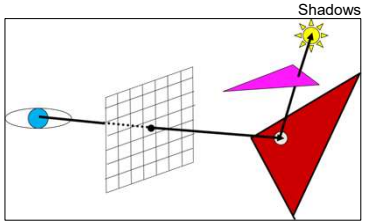
7

A Closest Hit Shader can also make calls to traceRay( )

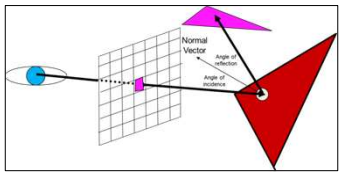
8



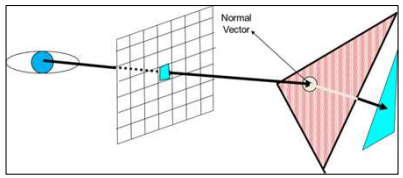
Shadows



Reflections



Refractions



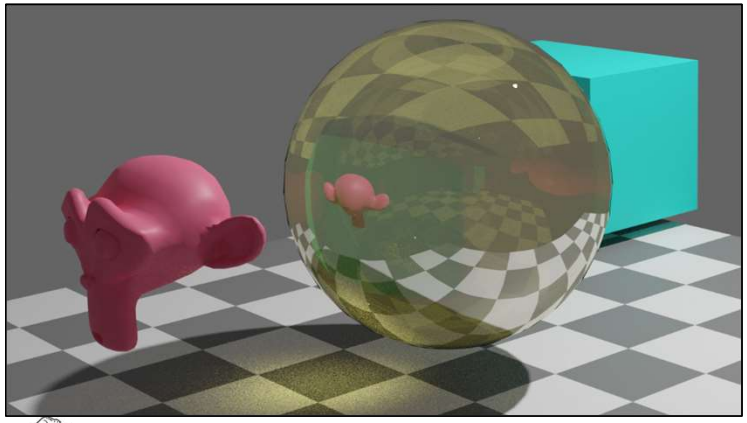
Oregon State University
Computer Graphics

mjb – March 5, 2023

8

Shadows, Reflections, and Refractions

9



Oregon State University
Computer Graphics

mjb – March 5, 2023

9