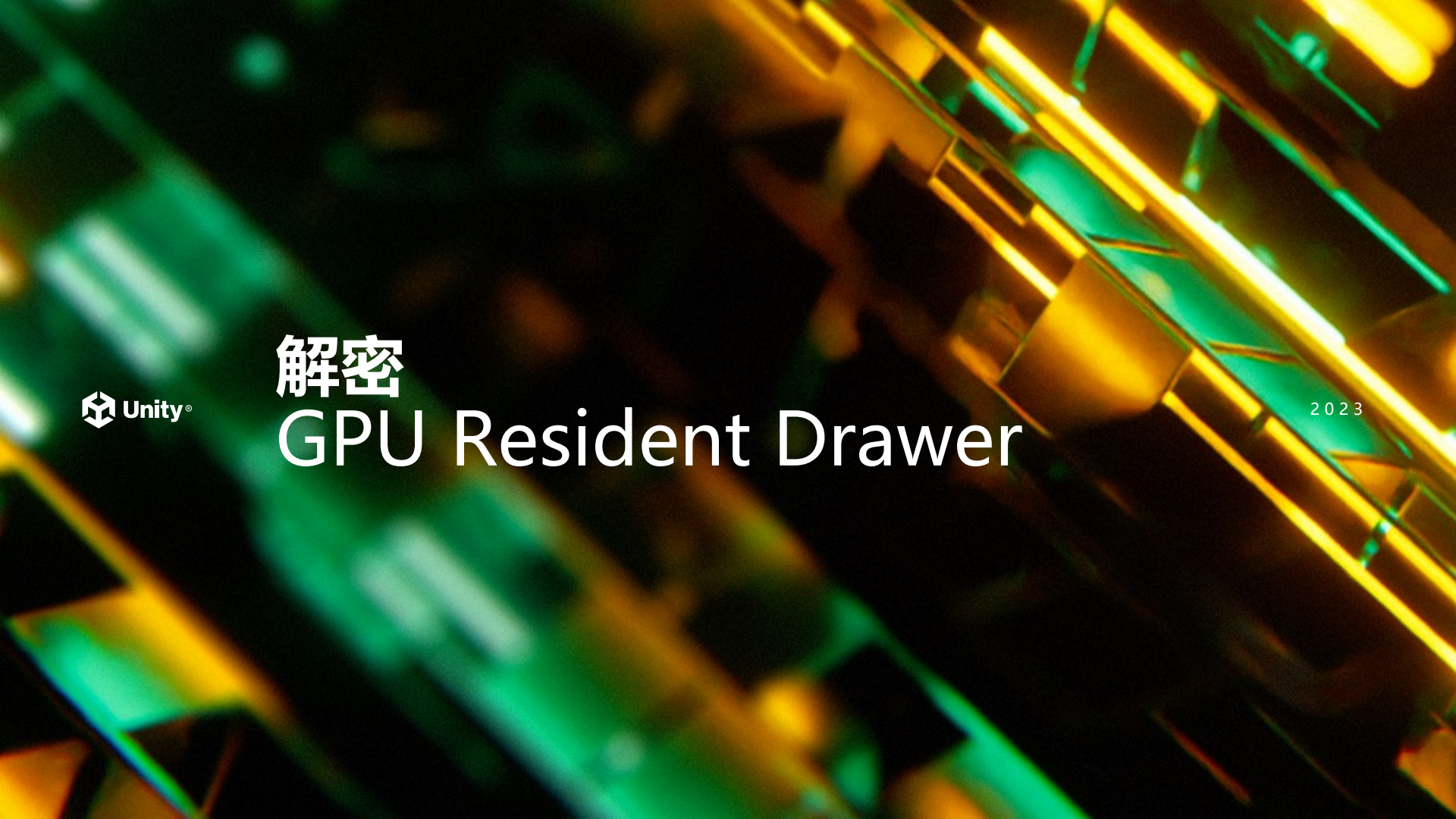
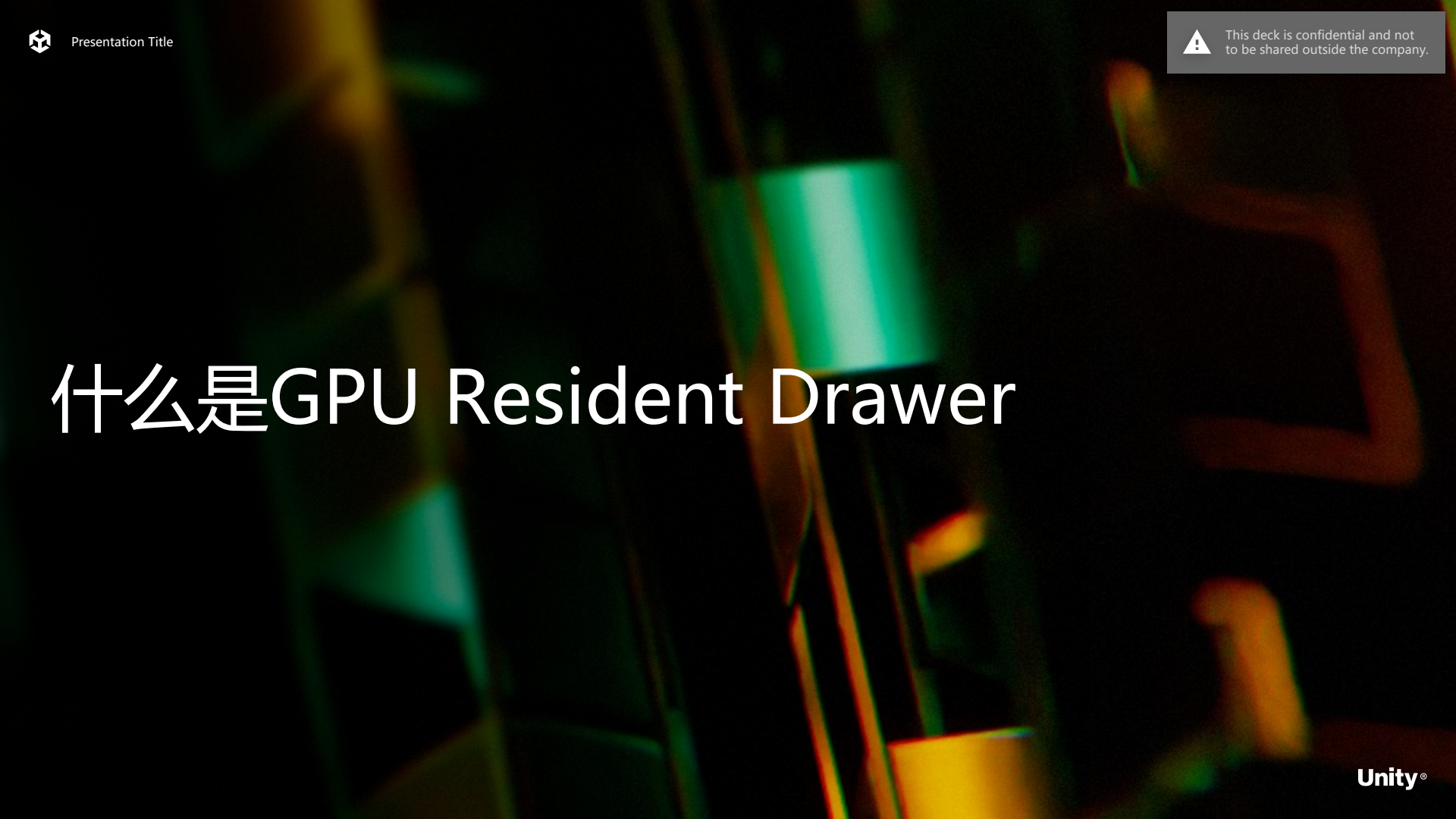

Unity
解密
GPU Resident Drawer
2023

GPU Resident Drawer

- 什么是GPU Resident Drawer
- GPU Resident Drawer 工作流
  - 组织batch
  - 裁剪
  - 输出DrawCommands

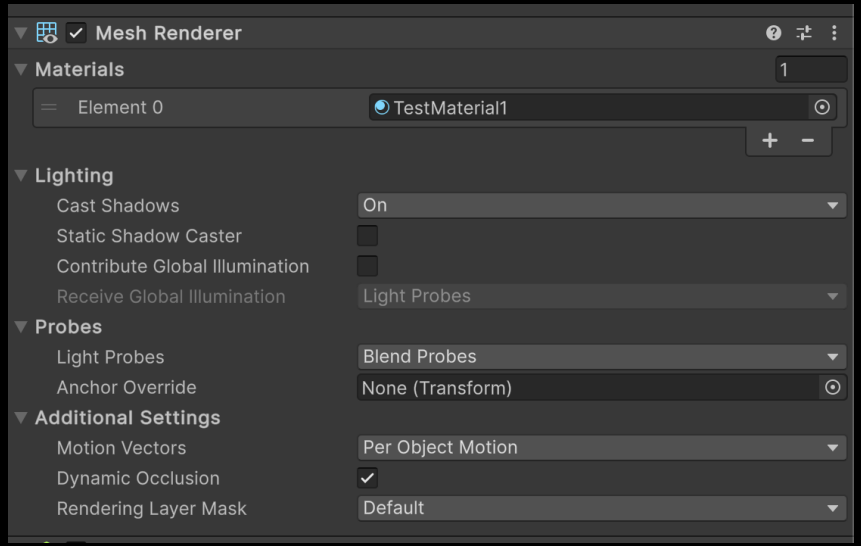
This deck is confidential and not to be shared outside the company.



什么是GPU Resident Drawer

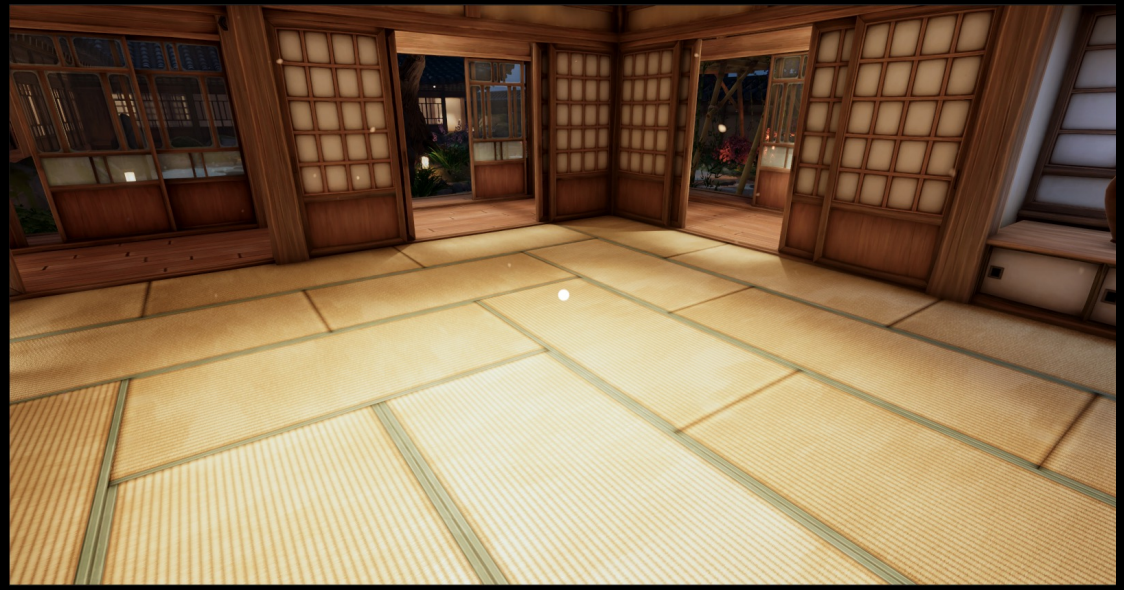
什么是GPU Resident Drawer

- → 基于Batch Renderer Group
- → 将MeshRenderer数据转换成BRG batch数据



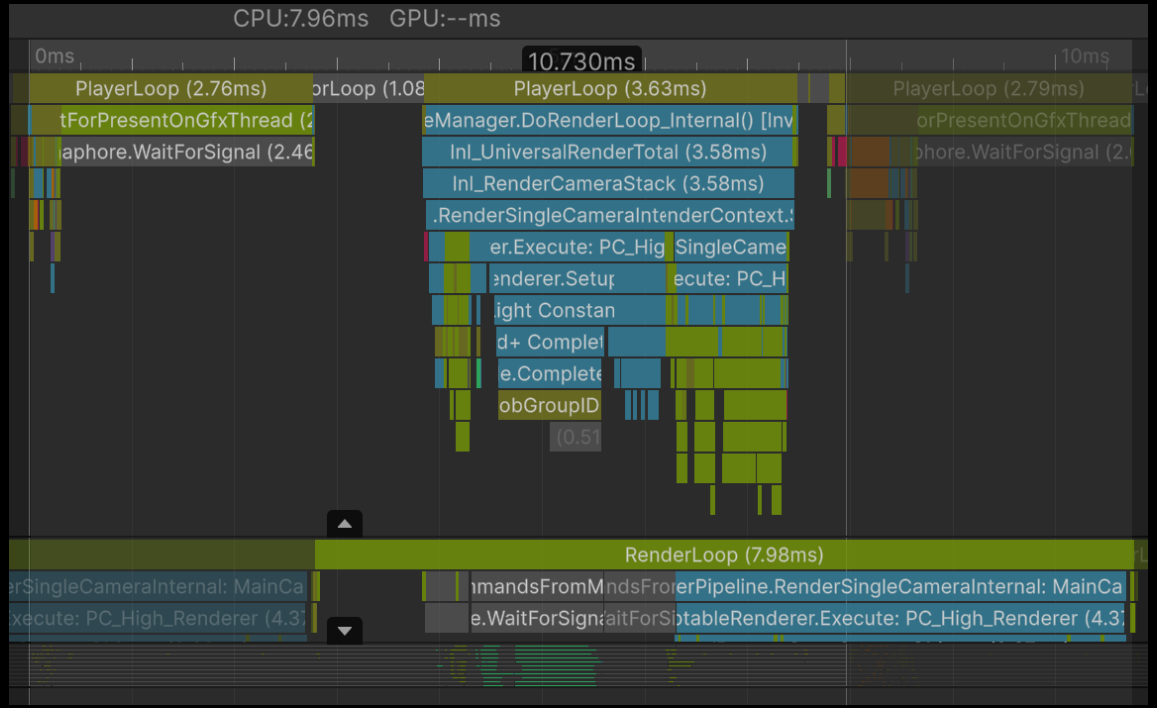
什么是GPU Resident Drawer

- → 相比传统SRP好处
- → Persistent batch
- → GPU persistent data model



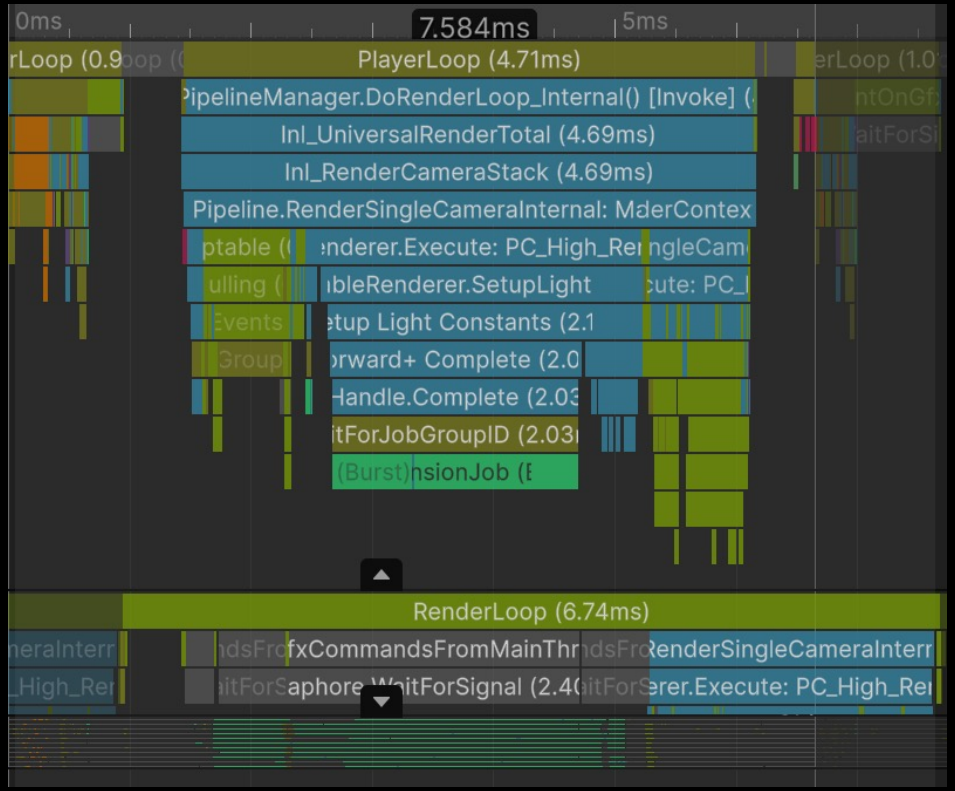
什么是GPU Resident Drawer

- URP
- 10.7ms



什么是GPU Resident Drawer

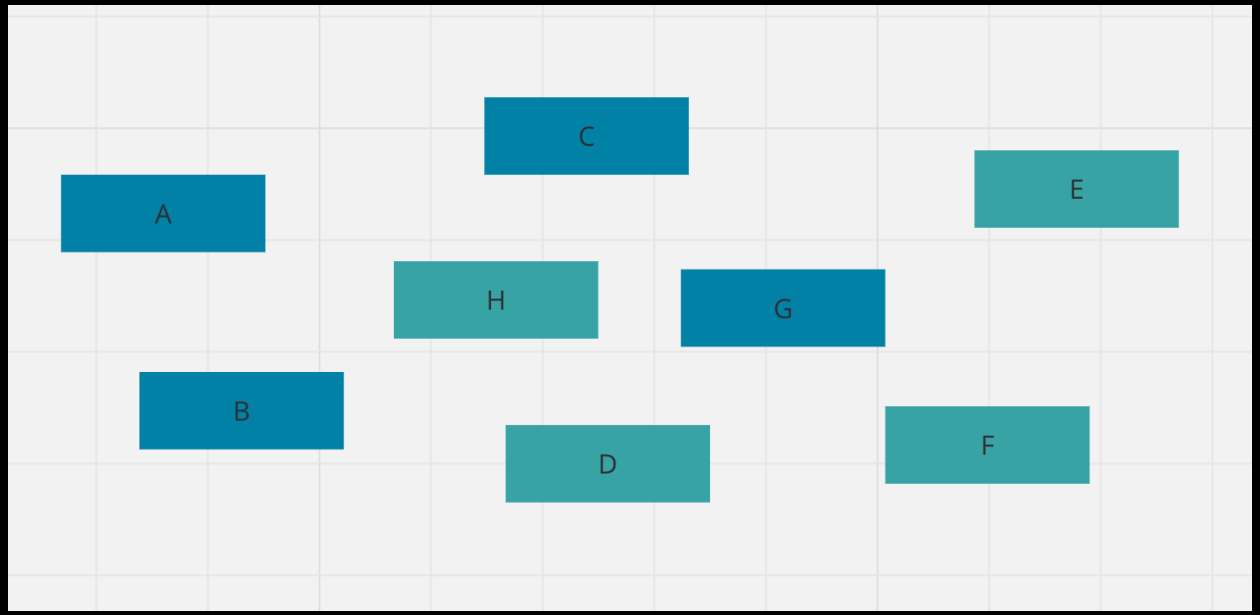
- → GPU Resident Drawer
- → ~7.5ms
- → 1.5x faster



Unity®

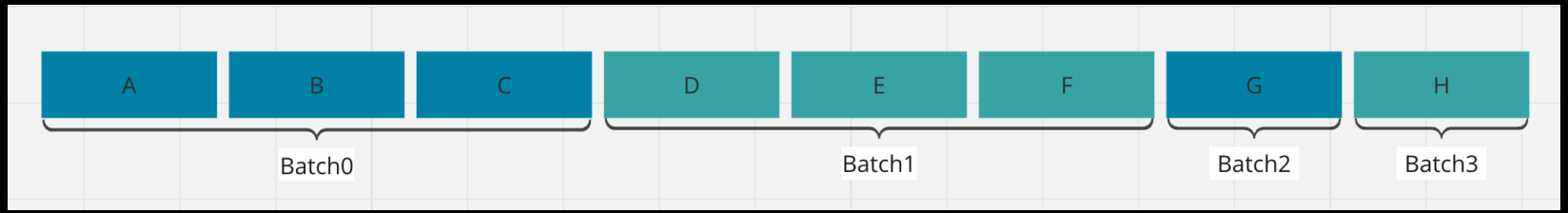
什么是GPU Resident Drawer

→ SRP如何组织数据



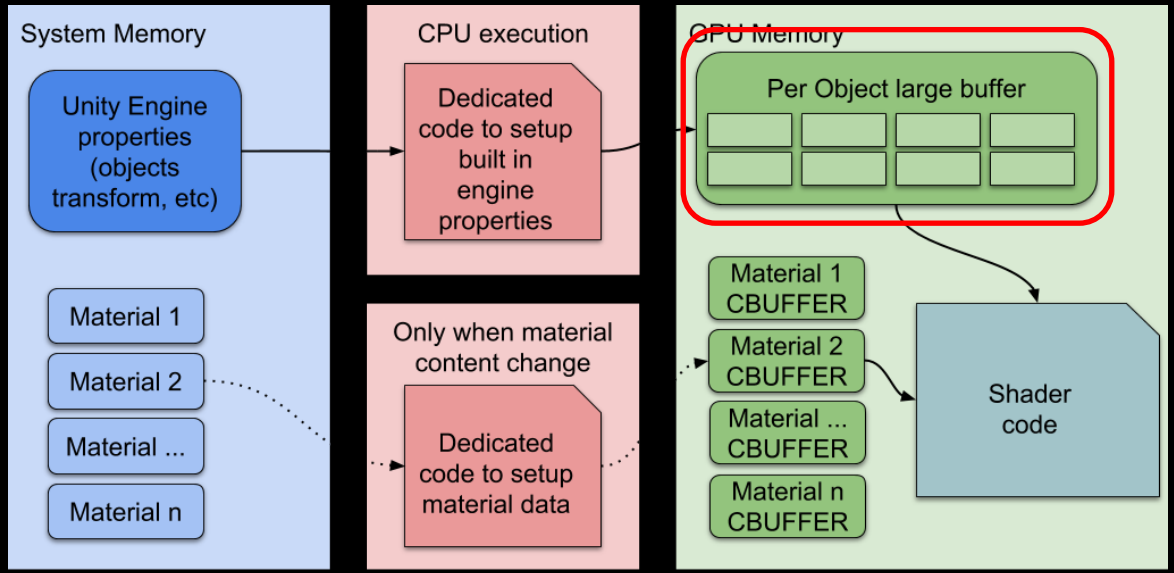
什么是GPU Resident Drawer

→ SRP Batcher如何组织数据



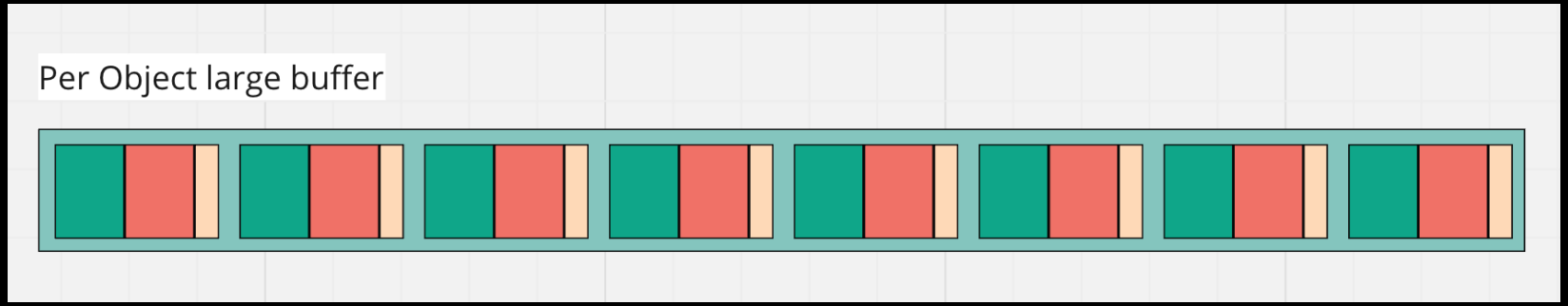
什么是GPU Resident Drawer

→ SRP如何组织数据



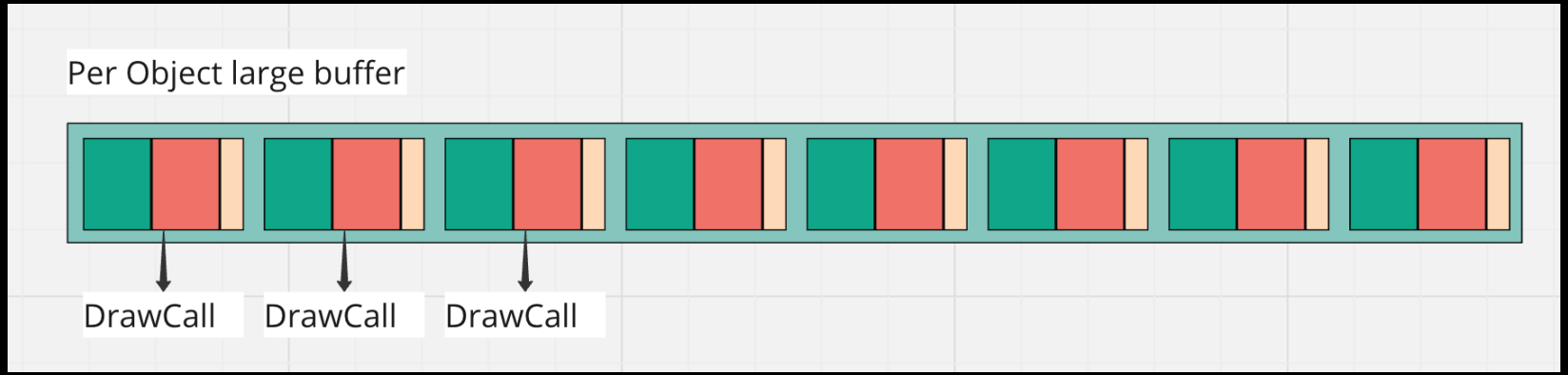
什么是GPU Resident Drawer

→ SRP如何组织数据



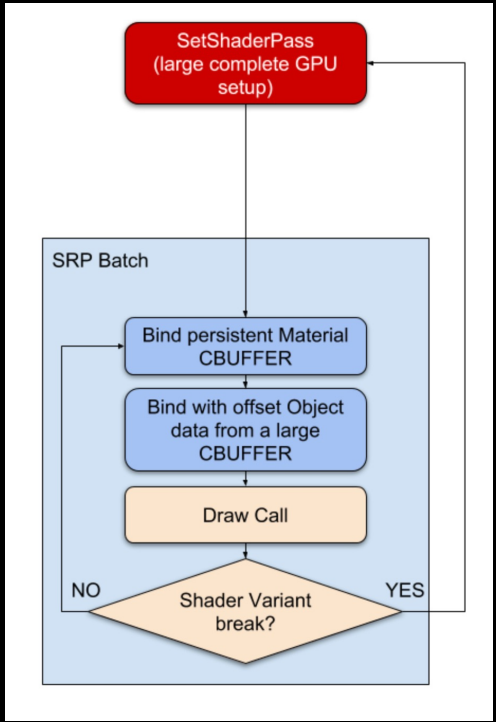
什么是GPU Resident Drawer

- SRP如何组织数据



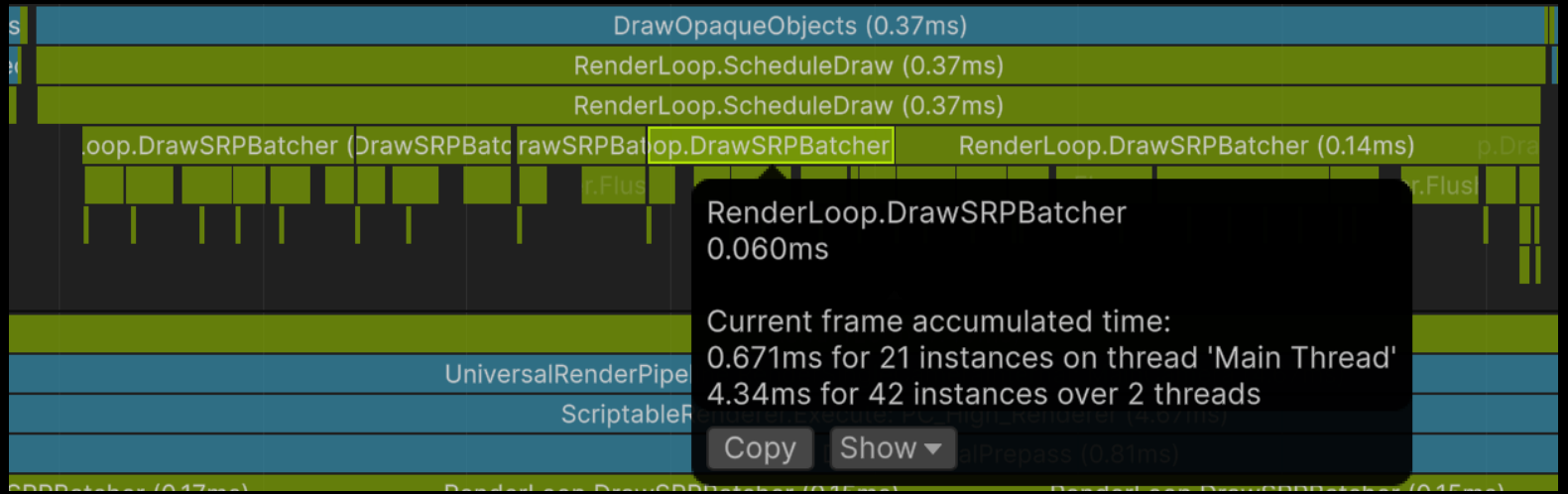
什么是GPU Resident Drawer

→ SRP如何组织数据



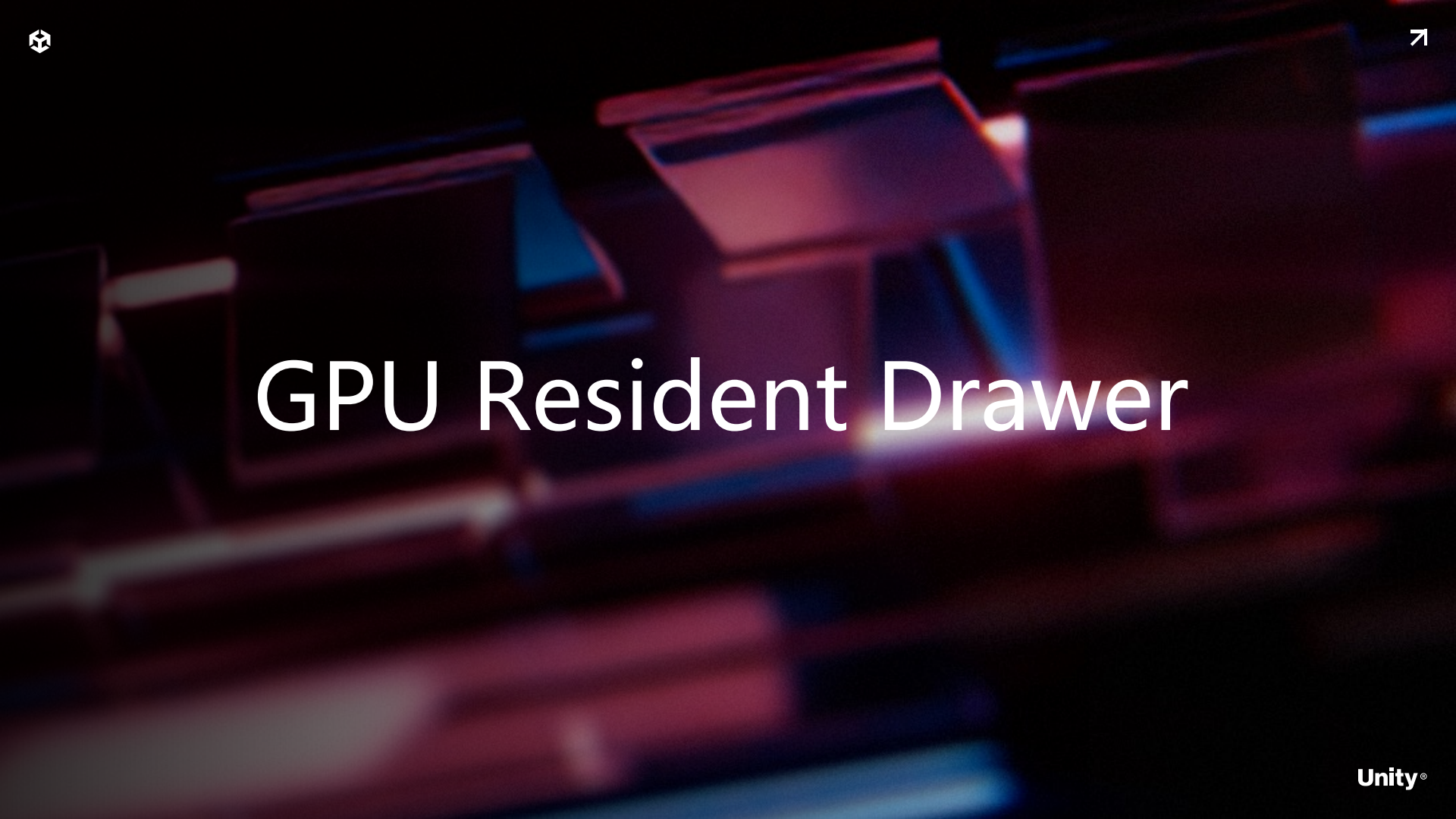
什么是GPU Resident Drawer

→ SRP Batcher单线程执行



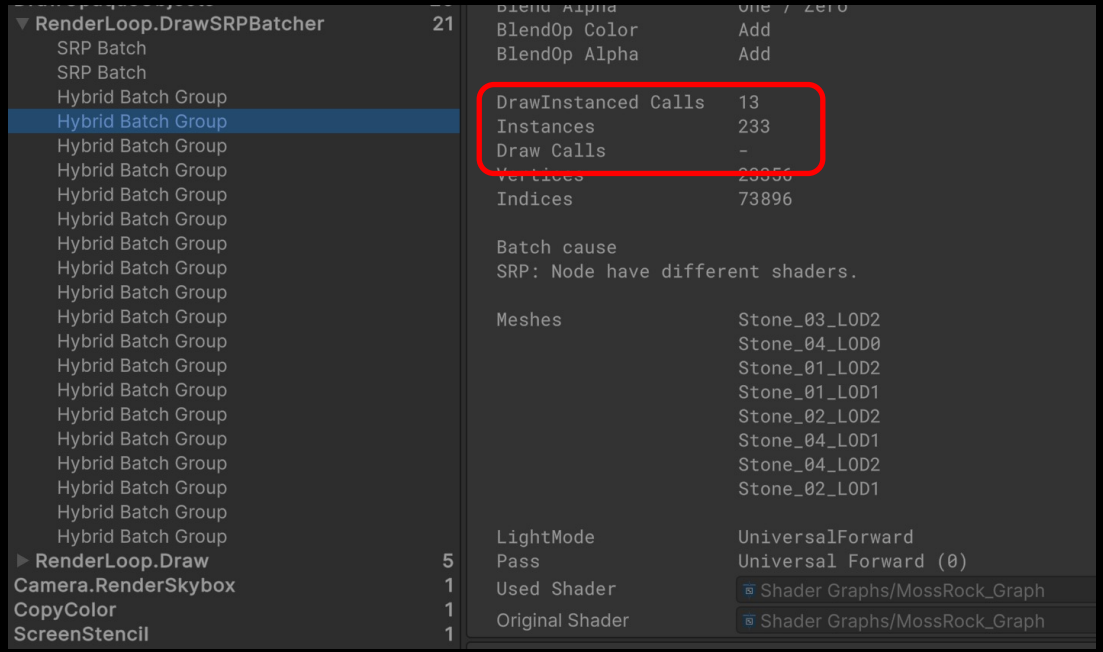
什么是GPU Resident Drawer

- SRP Batcher问题
- Batch根据传入的Renderer的顺序确定Batch
- 单线程


GPU Resident Drawer
Unity®

GPU Resident Drawer

→ FrameDebugger



GPU Resident Drawer

→ 基于Instancing技术

```
public static void DrawMeshInstanced(
    Mesh mesh,
    int submeshIndex,
    Material material,
    List<Matrix4x4> matrices,
    MaterialPropertyBlock properties,
    ShadowCastingMode castShadows,
    bool receiveShadows,
    int layer,
    Camera camera,
    LightProbeUsage lightProbeUsage,
    LightProbeProxyVolume lightProbeProxyVolume){...}
```

GPU Resident Drawer

→ 基于Instancing技术

```
public static void DrawMeshInstanced(
    Mesh mesh,
    int submeshIndex,
    Material material,
    List<Matrix4x4> matrices,
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    bool receiveShadows,
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    Camera camera,
    LightProbeUsage lightProbeUsage,
    LightProbeProxyVolume lightProbeProxyVolume){...}
```
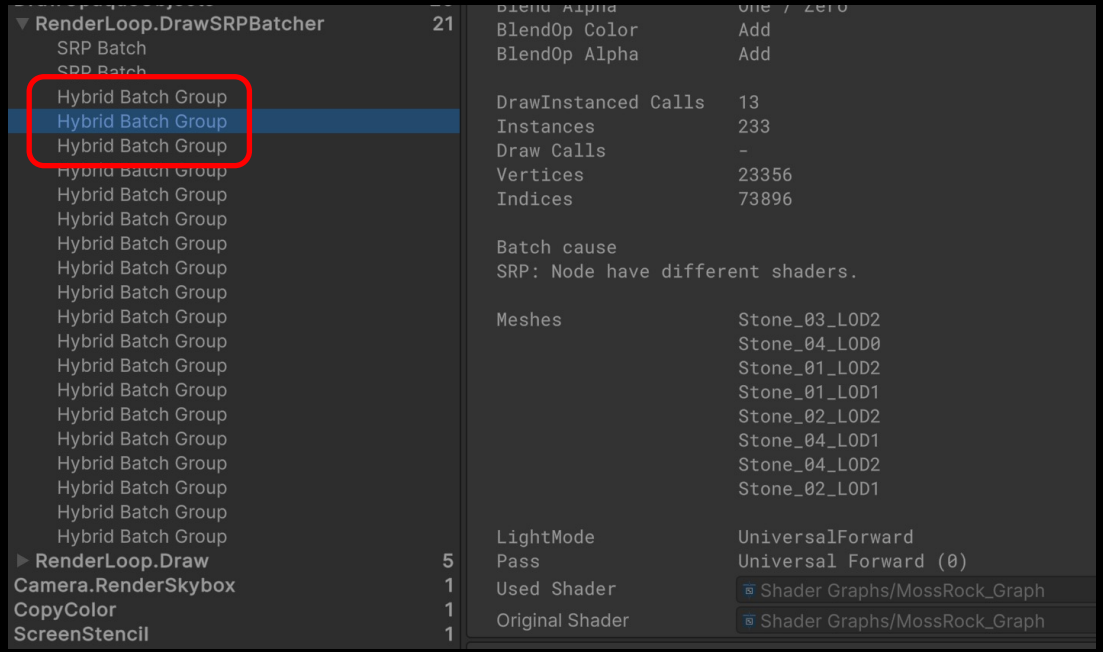

GPU Resident Drawer

→ 使用了Batch Renderer Group API



GPU Resident Drawer

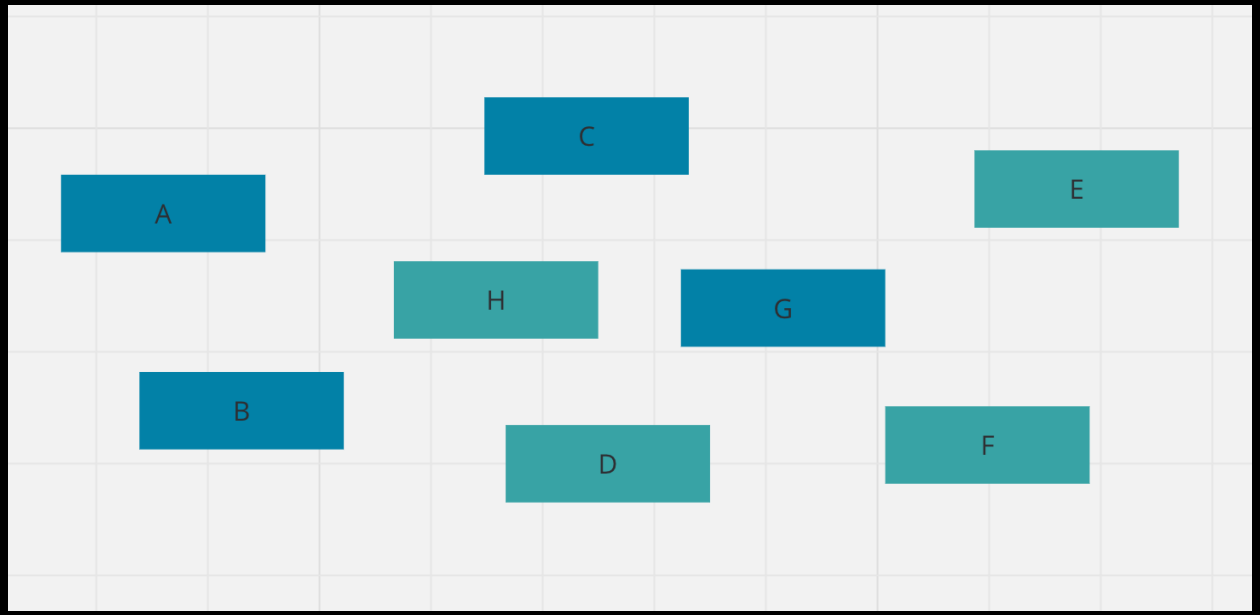
→ GPU Resident Drawer是Batch Renderer Group API的上层封装

→ 做了下面几项工作

1. 把Mesh Renderer的数据组织成BRG Batch
2. 上传Renderer数据到GPU
3. 对Renderer进行裁剪
4. 提交draw call

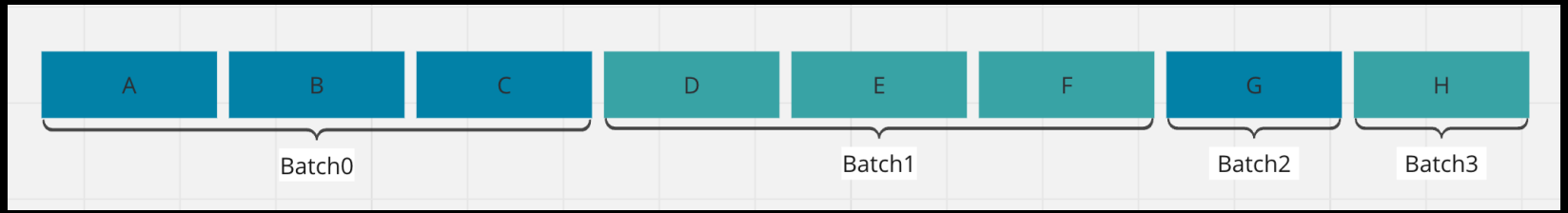
GPU Resident Drawer

- 组织Batch
- SRP Batcher VS Resident Drawer



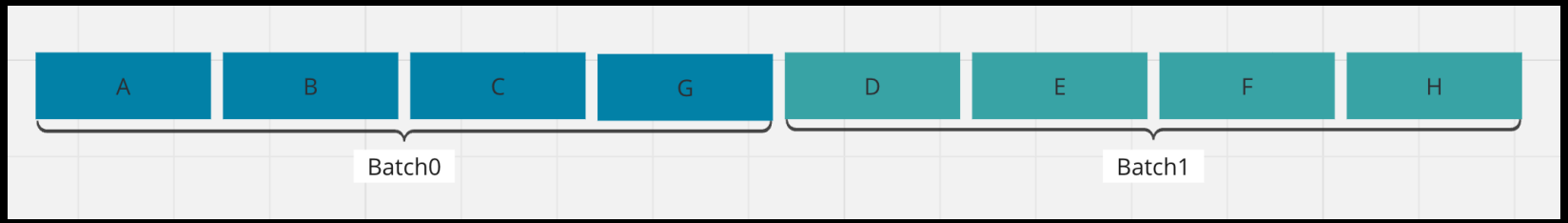
什么是GPU Resident Drawer

- SRP Batcher
- 按照Renderer顺序尝试合批



什么是GPU Resident Drawer

- Resident Drawer
- 对Renderer进行重映射（remapping），获得更少的批次

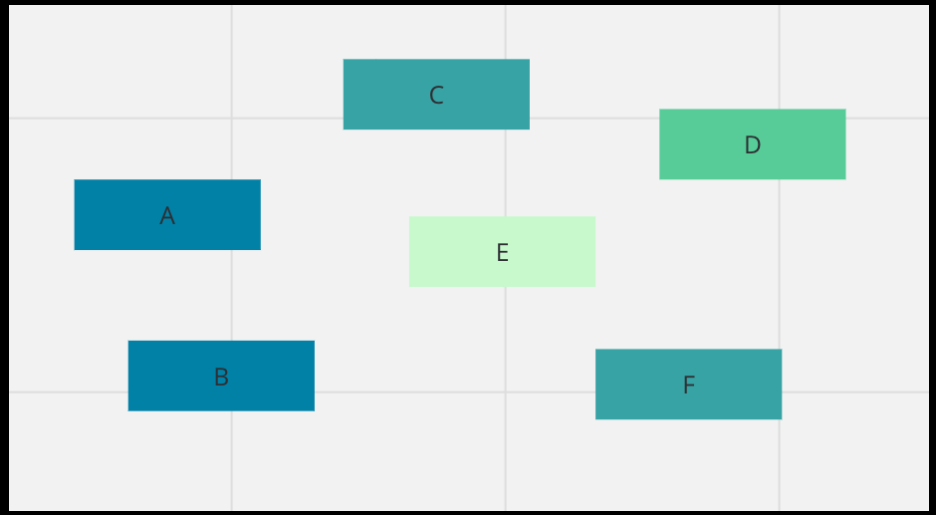


GPU Resident Drawer

- Resident Drawer如何做到更合理的组织Batch?

GPU Resident Drawer

→ Resident Drawer如何做到更合理的组织Batch?



GPU Resident Drawer

- Instancing技术限制
- 一次instanced call，需要传入一个mesh和一个material

```
public static void DrawMeshInstanced(
    Mesh mesh,
    int submeshIndex,
    Material material,
    List<Matrix4x4> matrices,
    MaterialPropertyBlock properties,
    ShadowCastingMode castShadows,
    bool receiveShadows,
    int layer,
    Camera camera,
    LightProbeUsage lightProbeUsage,
    LightProbeProxyVolume lightProbeProxyVolume){...}
```

GPU Resident Drawer

→ Resident Drawer如何做到更合理的组织Batch?

GPU Resident Drawer

→ Resident Drawer如何做到更合理的组织Batch?

```
public static void DrawMeshInstanced(
    Mesh mesh,
    int submeshIndex,
    Material material,
    List<Matrix4x4> matrices,
    MaterialPropertyBlock properties,
    ShadowCastingMode castShadows,
    bool receiveShadows,
    int layer,
    Camera camera,
    LightProbeUsage lightProbeUsage,
    LightProbeProxyVolume lightProbeProxyVolume){...}
```

GPU Resident Drawer

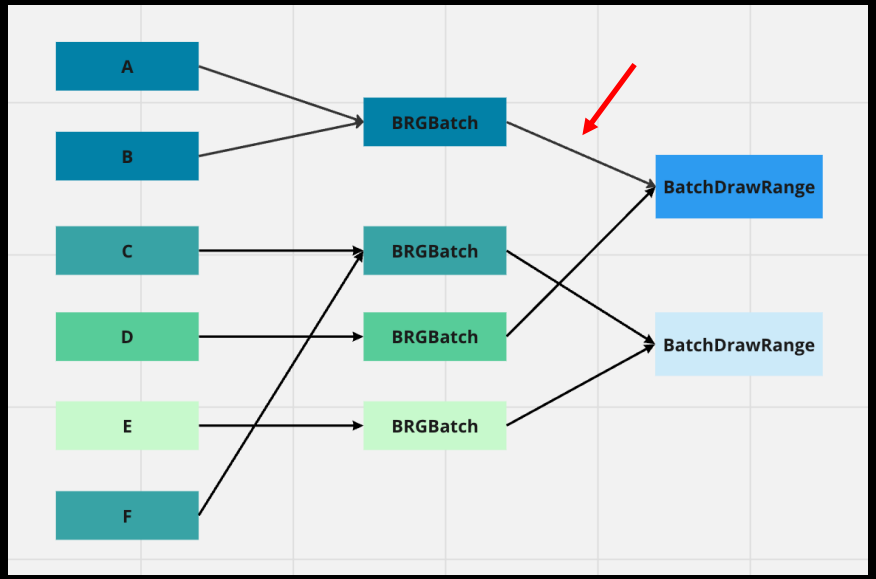
- DrawRange
- 一组连续的拥有共同过滤属性的Batch
- 类似SRP->FilteringSettings

```
public struct BatchDrawRange
{
    IL code
    public BatchDrawCommandType drawCommandsType;
    IL code
    public uint drawCommandsBegin;
    IL code
    public uint drawCommandsCount;
    IL code
    public BatchFilterSettings filterSettings;
}
```

```
var range = new BatchDrawRange();
range.filterSettings.shadowCastingMode = ShadowCastingMode.Off;
```

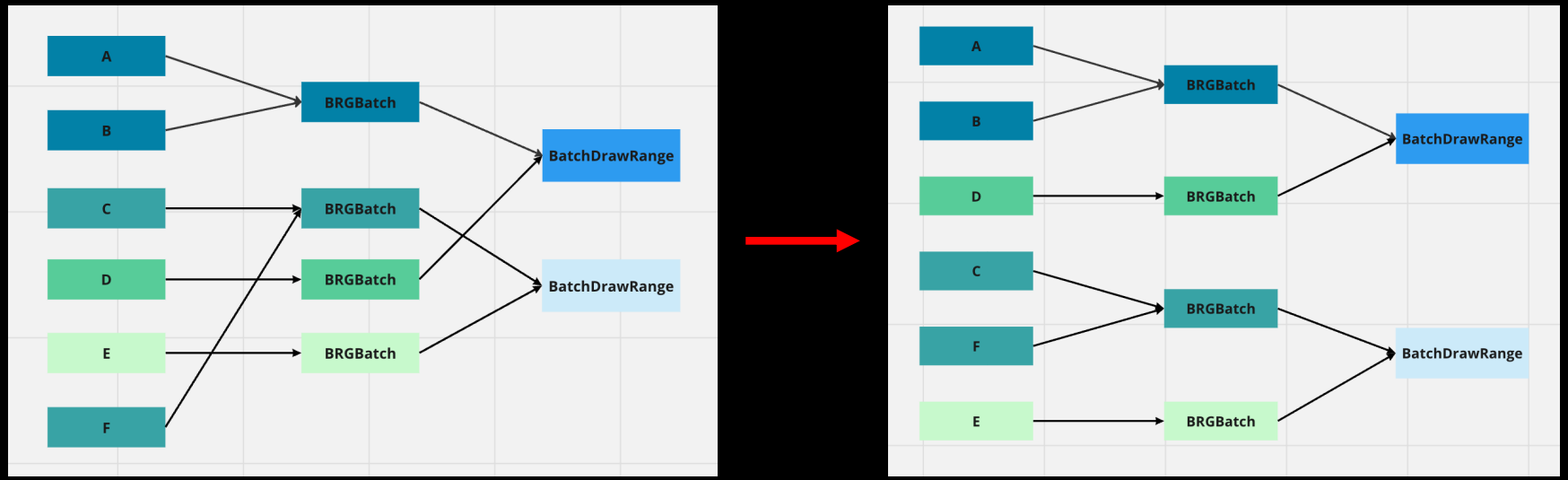
GPU Resident Drawer

→ 按照DrawRange进行分组



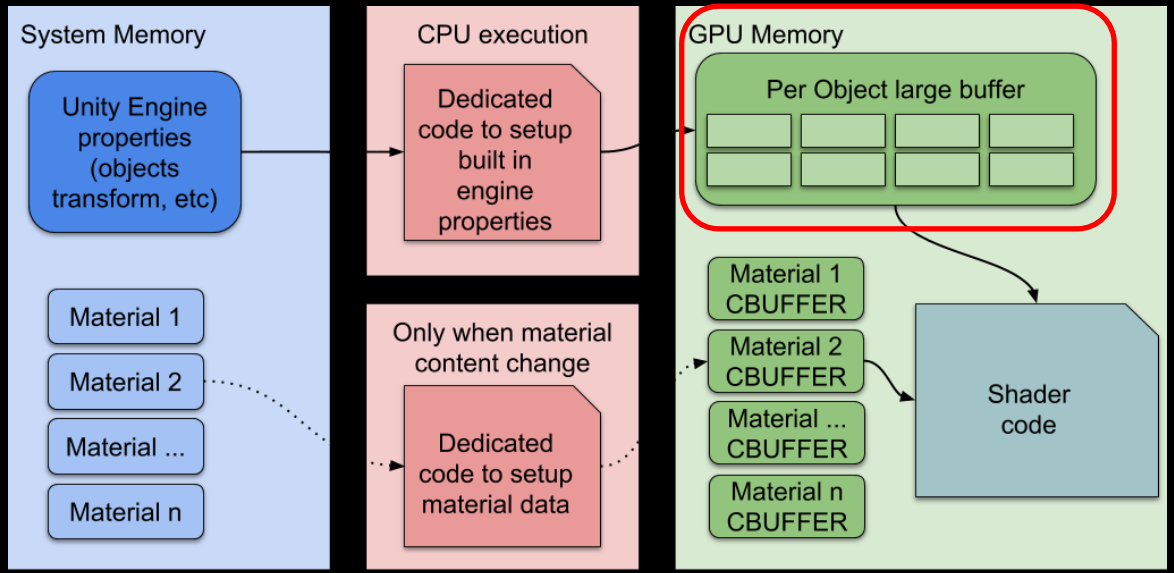
GPU Resident Drawer

→ 重映射Remap



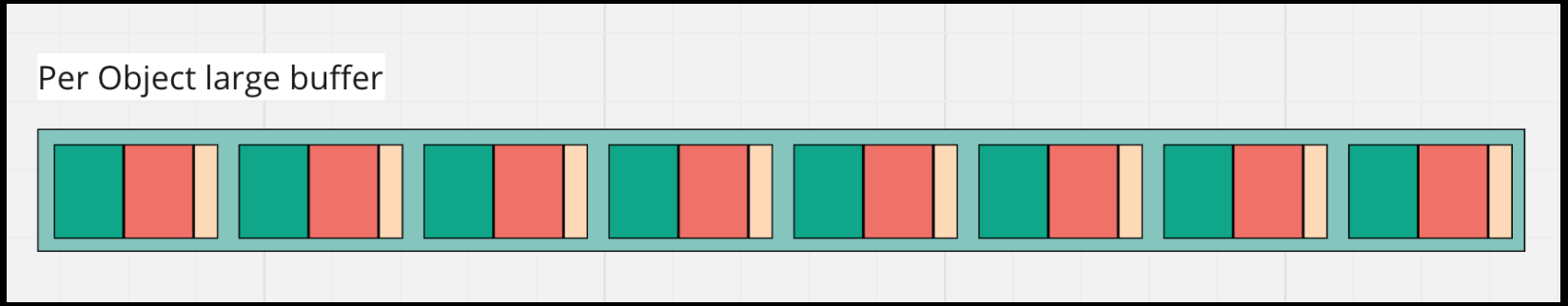
GPU Resident Drawer

→ 上传Renderer数据



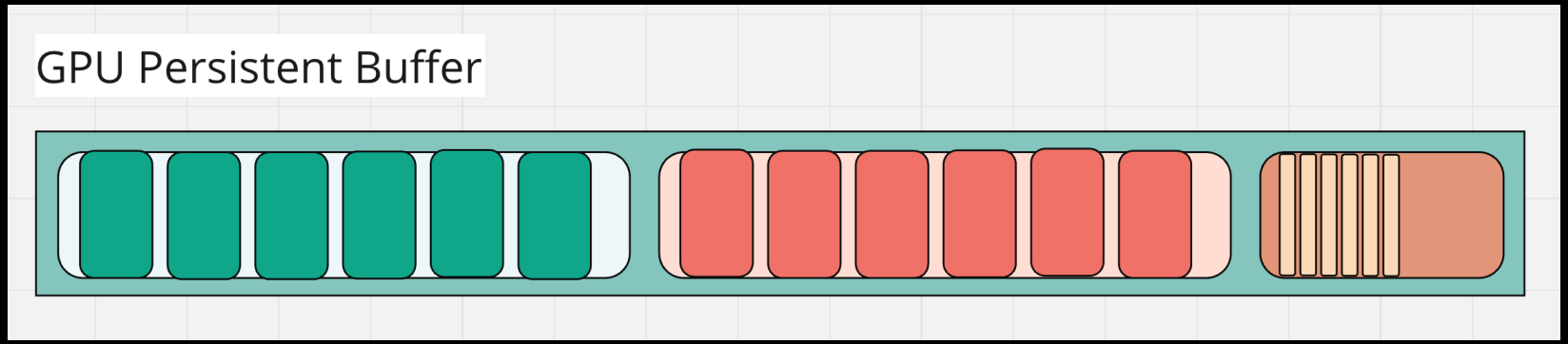
GPU Resident Drawer

→ SRP Batcher



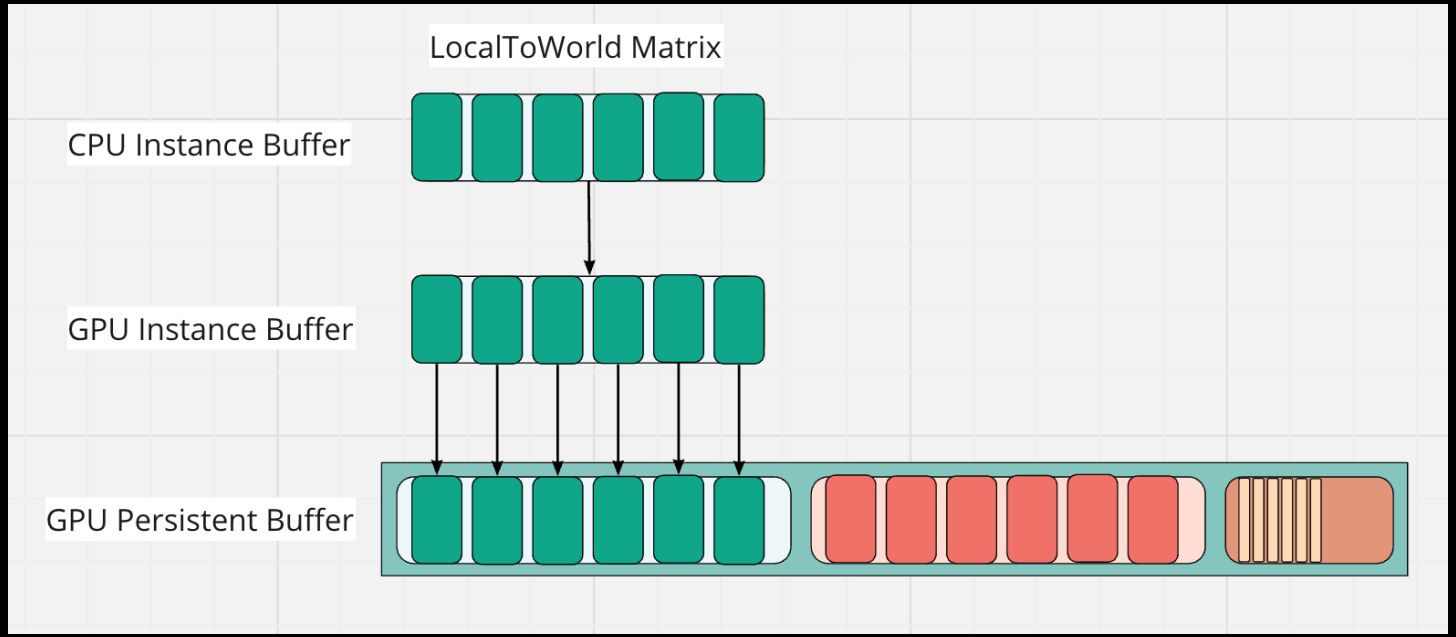
GPU Resident Drawer

- Resident Drawer
- SOA



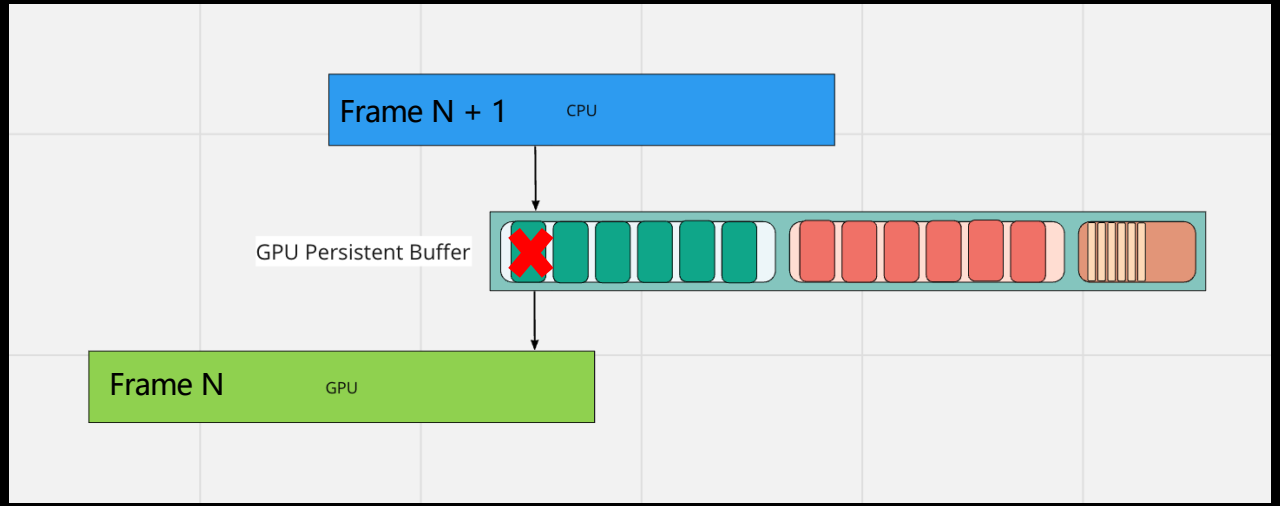
GPU Resident Drawer

- 上传数据
- 采用compute shader并行拷贝数据



GPU Resident Drawer

- 类似双缓冲设计
- 为什么?

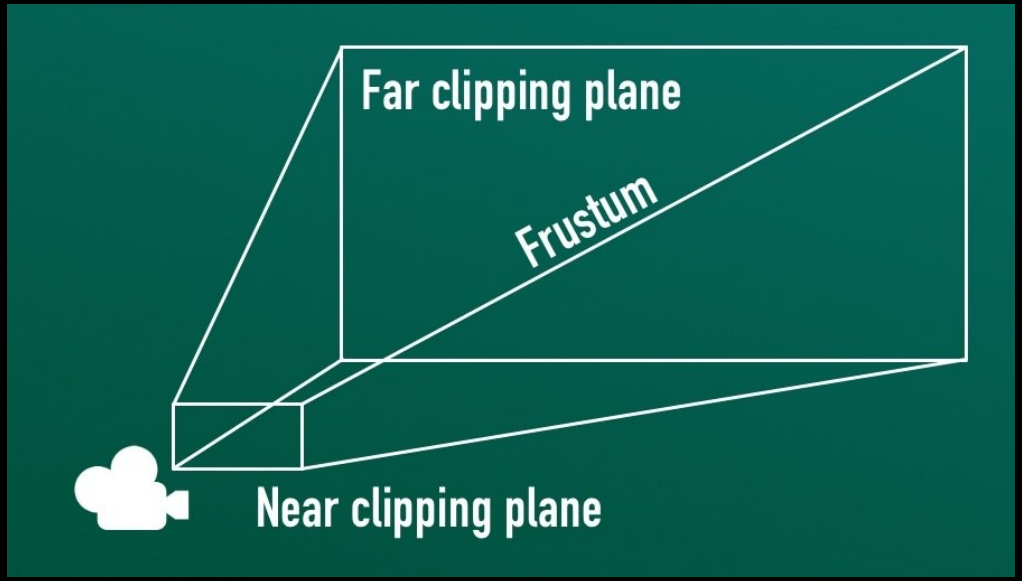


GPU Resident Drawer

- DrawMeshInstanced()
- 不支持裁剪，会渲染相机视口外的物体

GPU Resident Drawer

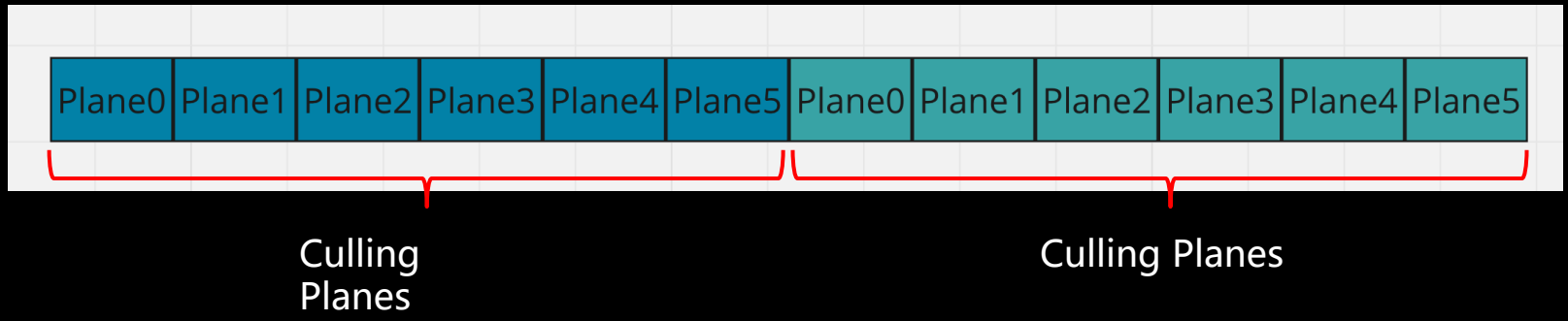
→ 裁剪



https://gamedevbeginner.com/how-to-zoom-a-camera-in-unity-3-methods-with-exan

GPU Resident Drawer

→ 裁剪



GPU Resident Drawer

裁剪会面临什么问题?

1. 一帧裁剪不只发生一次
2. 每个相机+每个灯光各裁剪一次
3. 当场景中绘制物体增多时，裁剪会成为性能瓶颈

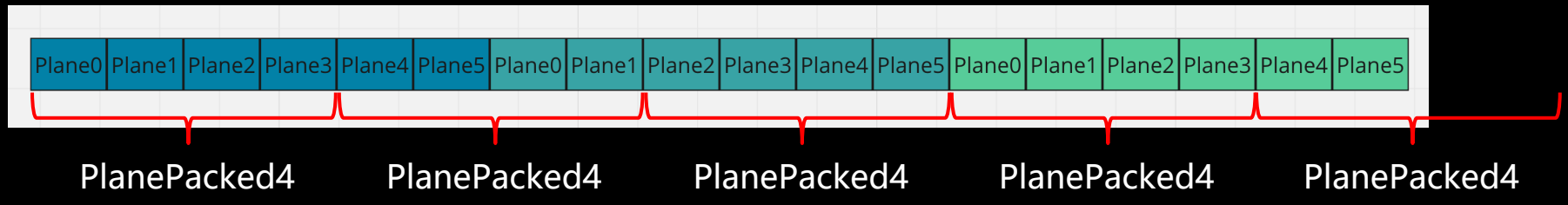
GPU Resident Drawer

如何解决?

1. 多线程
2. SIMD!

GPU Resident Drawer

→ 裁剪



GPU Resident Drawer

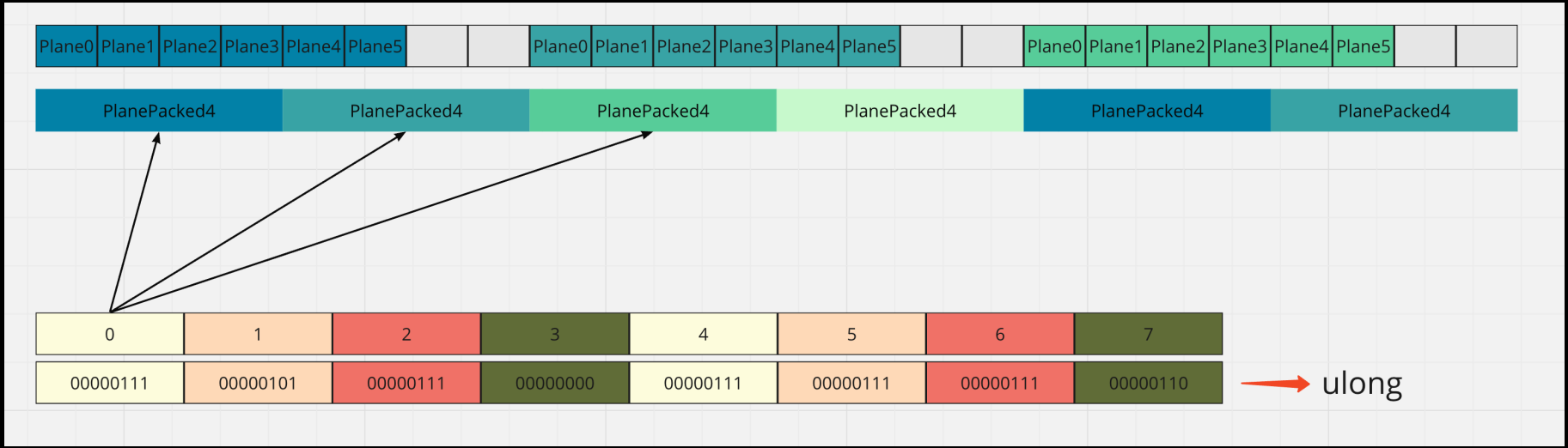
```
7 usages
public struct PlanePacket4
{
    public float4 Xs;          Serializable
    public float4 Ys;          Serializable
    public float4 Zs;          Serializable
    public float4 Distances;   Serializable
}
```

GPU Resident Drawer

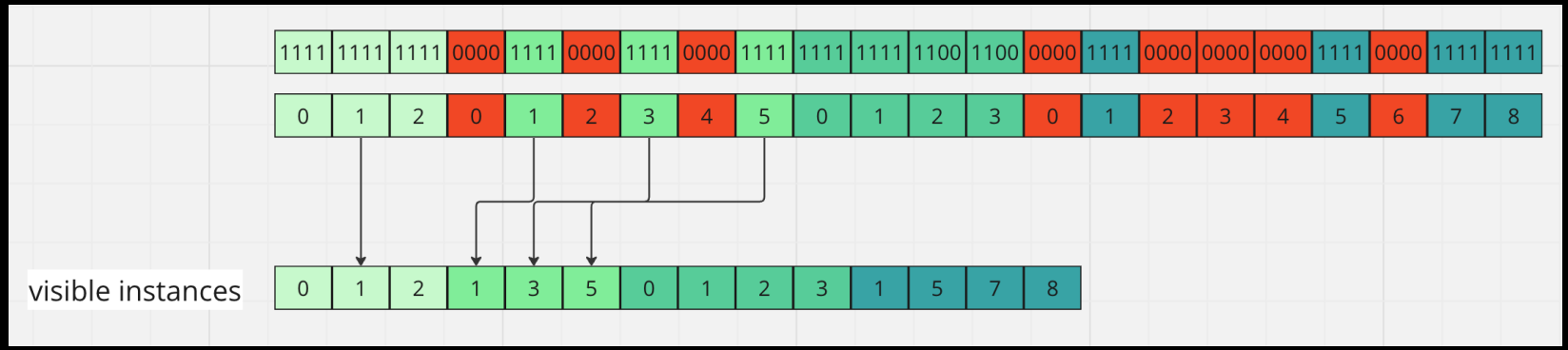
→ SIMD!

```
int4 masks = (int4)0;
for (int i = 0; i < packetCount; i++)
{
    var p:PlanePacket4 = cullingPlanePackets[offset + i];
    float4 distances = dot4(p.Xs, p.Ys, p.Zs, mx, my, mz) + p.Distances;
    float4 radii = dot4( xs: ex,  ys: ey,  zs: ez,  mx: math.abs(p.Xs),  my: math.abs(p.Ys),  mz: math.abs(p.Zs));
    masks += (int4)(distances + radii <= 0);
}

int outCount = math.csum(masks);
if (outCount == 0) outMask |= 1u << s;
```

GPU Resident Drawer



GPU Resident Drawer

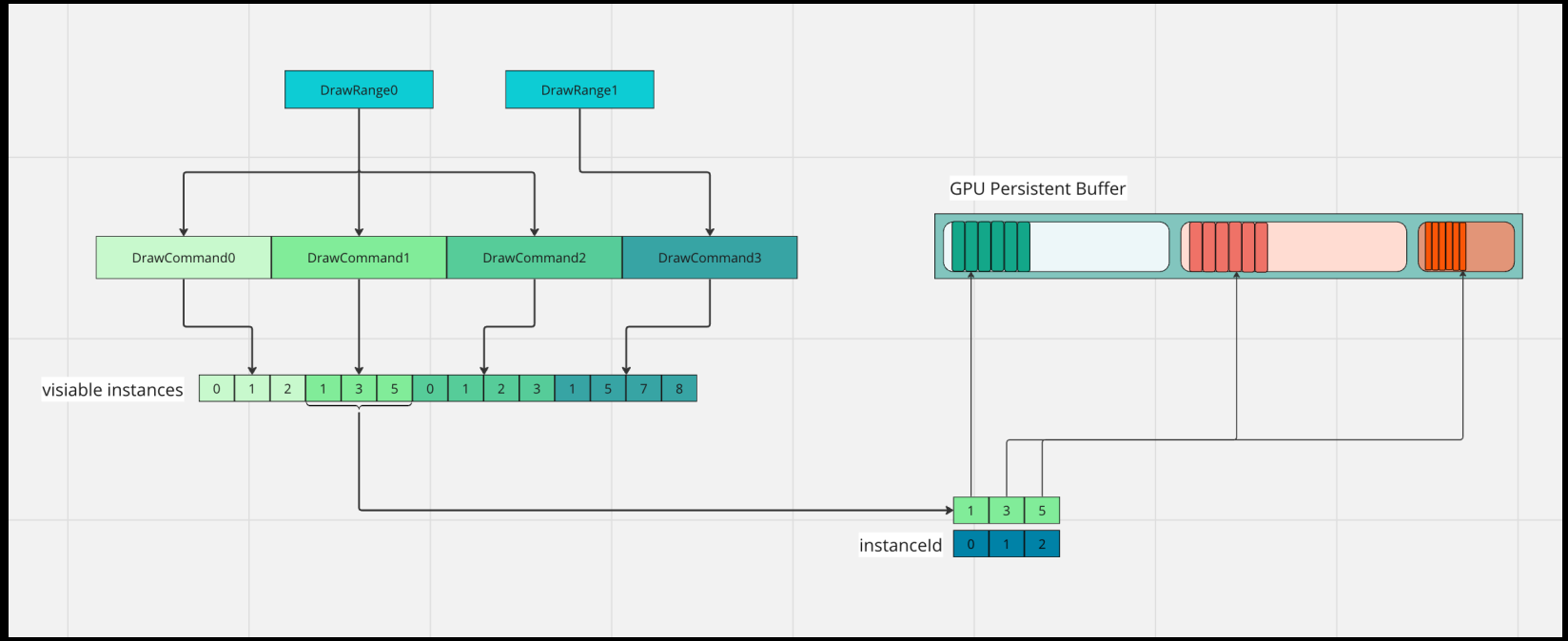


GPU Resident Drawer

到此为止

1. Batch组织 ✓
2. Renderer数据上传GPU ✓
3. Batch内的instance可见性 ✓

GPU Resident Drawer



GPU Resident Drawer

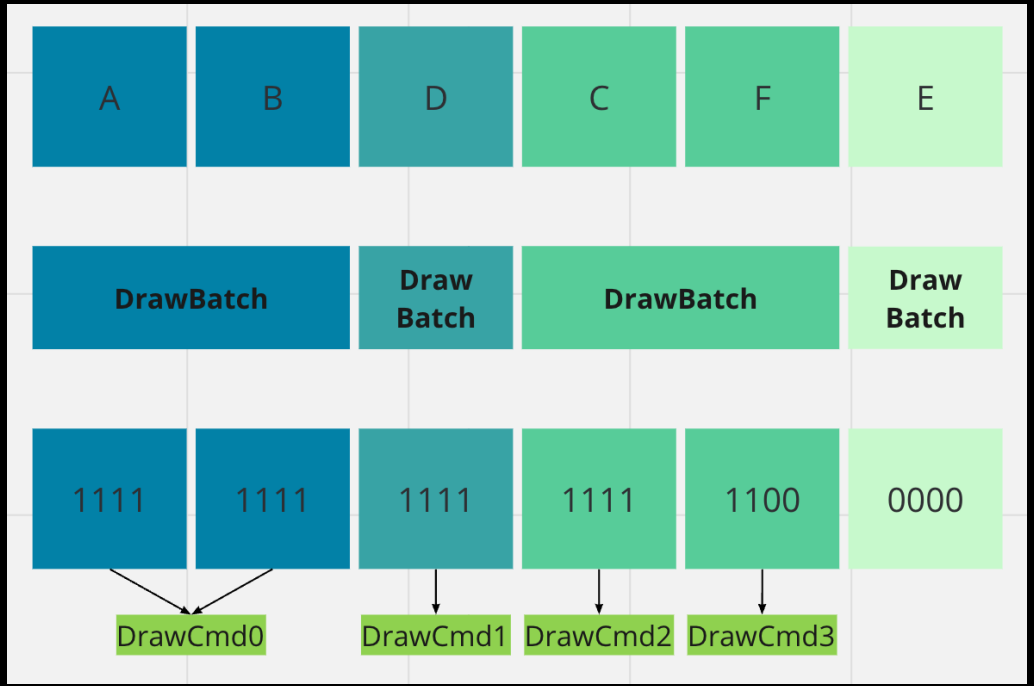
→ 提交DrawCall

```
public struct BatchDrawCommand
{
    public BatchID batchID;
    public BatchMaterialID materialID;
    public BatchMeshID meshID;
    public uint visibleOffset;
    public uint visibleCount;
}
```

```
public struct BatchDrawRange
{
    public BatchDrawCommandType drawCommandsType;
    public uint drawCommandsBegin;
    public uint drawCommandsCount;
    public BatchFilterSettings filterSettings;
}
```

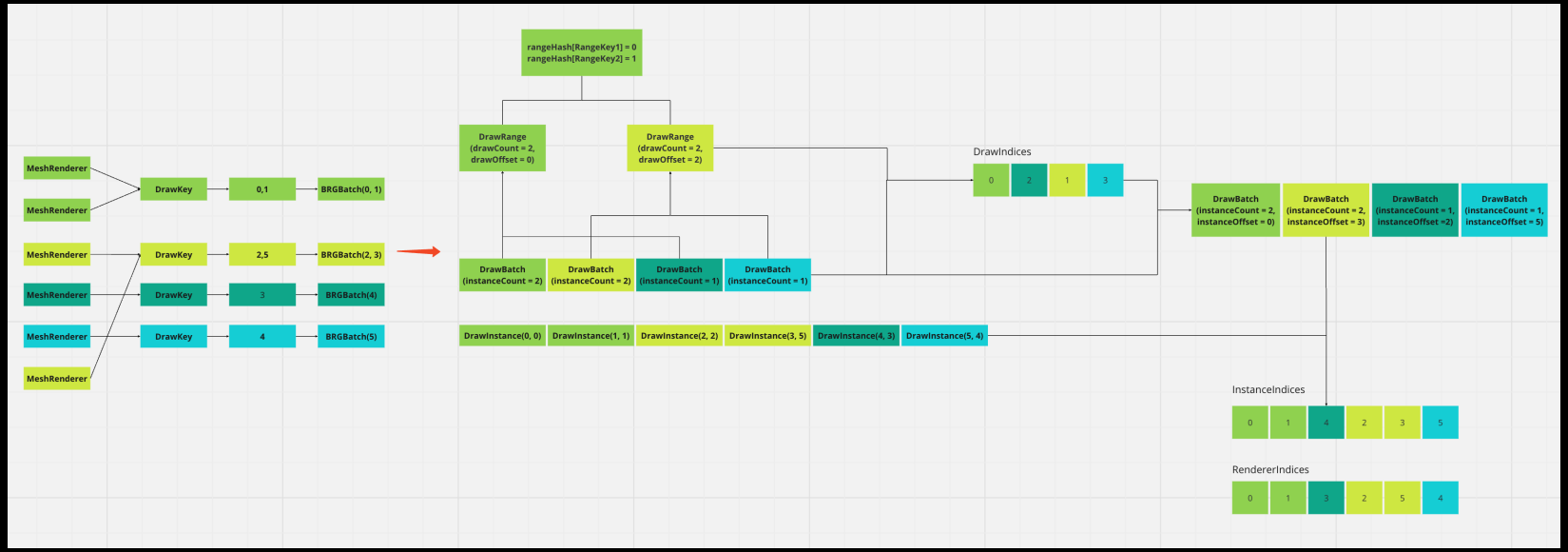
GPU Resident Drawer

→ 提交DrawCall



GPU Resident Drawer

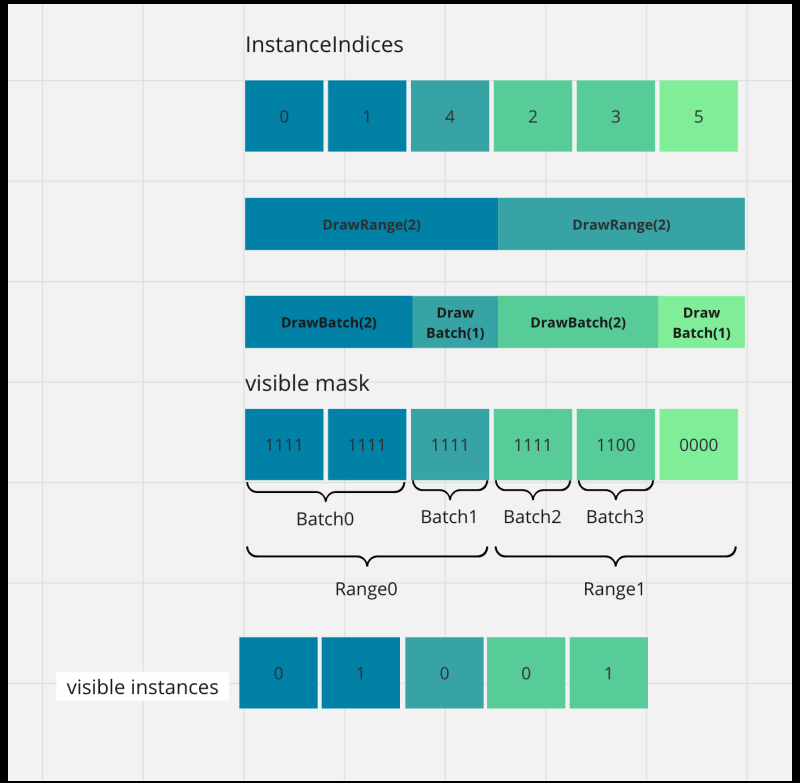
→ 组织batch



Unity®

GPU Resident Drawer

→ 提交DrawCall



Unity®

GPU Resident Drawer

- 总结
- 基于BatchRendererGroup API
- 把MeshRenderer转换成BRG batch
- 相比SRP Batcher可以提供更好的合批
- 并且优化了CPU->GPU的数据传输过程

GPU Resident Drawer

- Unity GPU Driven Tier0
- 主要优化批次组织和CPU->GPU的数据传输
- Unity6 BRG扩展了indirect和procedural两种新DrawCommand
- 当前Unity6 alpha版本支持GPU Driven Tier1 => GPU Culling